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ABSTRACT

This collection of six papers discusses various aspects of teaching basic skills in connection with vocational education. The six papers are the following: "Basic Academic Skills in the Workplace and the Classroom: The Work-Education Bridge" (James A. Pershing, Scott W. Gillie); "Basic Literacy and Communication Skills for Vocational Training" (Larry Mikulecky, Rad A. Drew); "Basic Mathematical Skills for Vocational Education" (Scott W. Gillie, Peter Kloosterman); "Basic Science Skills in Vocational Education" (Debra Moore, Harold Harty); "Computer Literacy and Basic Skills in Vocational Education" (James A. Pershing, Patricia J. Rutan); and "Indiana Commission on Vocational and Technical Education Projects and Initiatives: The Impact and Potential of Basic Academic Skills" (Scott W. Gillie). Each paper contains reference lists. (KC)

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A Basic Skills Collection

Bridging Education and Employment with Basic Academic Skills

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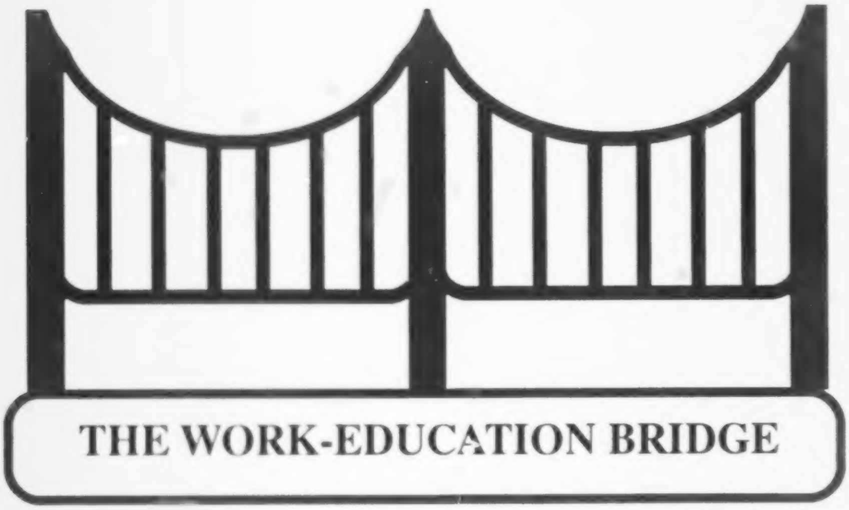

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A Basic Skills Collection

Bridging Education and Employment with Basic Academic Skills

James A. Pershing, Ph.D., Editor

The Office of Education and Training Resources
School of Education
Indiana University
Bloomington, Indiana
47405

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Appreciation also is extended to the staff of Vocational Education Services. Their support and technical assistance were vital to the successful completion of the WEB project.

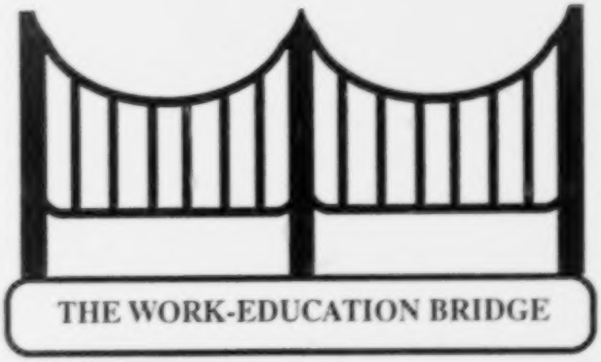
James A. Pershing, Ph.D.

CHAPTER ONE

Basic Academic Skills in the Workplace and the Classroom: The Work-Education Bridge

by

James A. Pershing, Ph.D.
Scott W. Gillie


THE WORK-EDUCATION BRIDGE

SPRING 1988

Basic Academic Skills in the Workplace and the Classroom: The Work-Education Bridge

by
James A. Pershing Ph.D.
Scott W. Gillie

In 1987, a group of Indiana University (IU) researchers set out to develop a workable model that would enable vocational educators to teach basic academic skills in vocational settings. Their effort, termed the Work-Education Bridge (WEB), provides educators with a methodology for identifying academic skills that are basic to a vocational area.

As part of the WEB Project, the IU group refined procedures for identifying basic academic skills specific to a particular occupation. They used techniques derived from the field of occupational task analysis. Furthermore, they developed and pilot tested a set of procedures for converting the basic academic skills content of occupations into instructional materials.

Several assumptions provide the basis for the WEB approach:

o People acquire basic academic skills more quickly and retain more when the skills are learned in conjunction with job-related applications.

o Work-related problem solving helps the vocational student to learn basic academic skills.

o Problem solving that is job-related involves the vocational student in a more holistic approach to learning and leads to a greater appreciation of the value, relevance, and application of basic academic skills.

o Work activities involve several skills (e.g., reading, computation, recording data, and extrapolation) that are used interdependently on the job. A worker must select, sequence, correct, and evaluate when he performs these skills. Therefore, these skills should be taught in a context that simulates the interdependant functioning of the workplace.

o The use of a task analysis process to identify the basic academic skills content of an occupation leads to a closer approximation of the work environment in the classroom. Using such a process can and should be a part of a vocational teacher's normal responsibilities.

o For some students, the most direct route to higher levels of basic academic skills is through vocational education.

o Vocational educators are willing to assume a key role in developing the basic academic skills of vocational students.

o Teaching basic academic skills in a specific vocational context may lead to competencies that the student does not generalize well to other application contexts.

o Teaching basic academic skills in a general context may lead to rote understanding accompanied by a high degree of loss in retention over a short period of time. Furthermore, the learner may be unable to apply the knowledge that is retained.

o Problem-solving and critical-thinking are metacognitive skills that are important to both academic and occupational success. There seems to be little connection between the problem solving that occurs in classrooms (especially academic ones) and the problem solving that is performed on the job. However, it may be possible to teach a generalizable approach to problem solving and critical thinking that would help students apply their knowledge and skills in both academic and occupational settings.

The WEB Project began with a review of literature that was broken down into five parts: mathematics, language, science, computer, and general basic academic skills. A review of practice followed, which involved a national solicitation to identify state-of-the-art resources in basic skills. Finally, a telephone survey of policy makers, administrators, state agency staff, and teacher educators was conducted in Indiana to identify programs and practices impacting basic skills development.

The literature review shed light on many of the assumptions stated above. All phases of the Project suggest that there is a sense of urgency about basic academic skills in both the vocational education community and the population at large. There is also an indication that many of the politically- initiated responses to basic academic skills are lacking in vision and understanding. A huge industry has developed around concerns associated with basic skills development, and there is little to suggest that the industry has a coherent understanding of the nature and extent of the problem, or of possible solutions.

Although there is consensus about the urgency to teach basic skills, there is little consensus about what skills are basic. A major goal of the WEB process is to provide a means to identify the academic skills that are basic to successful job performance in a particular occupation.

Current Practice in Basic Academic Skills Instruction

The responses to the national solicitation and to the results of the Indiana survey about practice suggest that basic academic skills instruction takes place mostly outside the vocational classroom. Subject-oriented classes (e.g., math, reading, technical writing) taught by academic departments, remedial teachers and the staff of learning skill centers are most often used to teach basic academic skills. For the most part, these skills are taught as generalizable skills; that is, without specific application to the students' vocational concentration.

Current practice may be classified under three distinct approaches; combinations of the first two approaches listed below are the most common practice.

1. **The Academic Approach.** In this turf-conscious orientation, basic academic skills are considered "pre-vocational." Vocational educators rely on their academic counterparts to supply students who have a command of the basics. If students enter vocational programs unskilled in the basics, vocational educators believe the fault lies with the academic program.

2. **The General Approach.** In some vocational settings, basic academic skills are viewed as fundamental. Therefore, every vocational student must learn universal necessities such as the parts of speech and how to solve simple mathematical equations. The vocational program is supplemented by special remedial classes, core requirements such as technical writing and mathematics, or enrollment in a learning skills laboratory. The general approach attempts to provide what the vocational program views as essential knowledge for all of its students.

3. **The Vocational Approach.** In this approach, basic academic skills are viewed by vocational administrators and teachers as essential aspects of the vocation. Instructional materials for basic academic skills are routinely available within the vocational classroom, and the vocational teacher views him/herself as a facilitator of whatever learning is essential for effective job performance.

The basic academic skills methodology that best fits the compartmentalized design of public education and appeals to most funders is characterized by isolated subject-matter, fragmented topics, abstract concepts, and the avoidance of activities that require students to manipulate ideas or concepts. This is a methodology that is marketable to the widest possible audience. The result is basic academic skills instruction that is divorced from practical application. For many students, this separation contributes to their sense that learning is somehow separate from life.

In all five parts of the literature review, the research team affirmed the importance of learning that is linked with practical applications, or praxis. Nonetheless, the literature also supports the conclusion that delivery systems often are shaped by forces that are collectively greater than matters of pedagogical soundness.

Three Delivery Systems for Basic Academic Skills

Campbell-Thrane et al. (1983) describe three models for basic academic skills instruction in conjunction with vocational education: integrated, nonintegrated, and combination. (p. 25) These models closely parallel the current practices described above by the Web Project.

> The integrated model represents an effort to teach basic skills in the vocational classroom whenever it is appropriate to the needs of students. Vocational teachers identify basic skills requirements for their career areas and teach these skills in conjunction with the vocational content.
>
> The nonintegrated model is fairly traditional: basic skills are taught in a classroom setting separate from vocational training. Responsibility for basic skills instruction rests with subject matter specialists rather than vocational teachers.
>
> The combination model is a blend of the integrated and nonintegrated models; elements of each are chosen based on the needs and resources of the particular school district. This model varies with administrative structure, budget, and other pertinent variables.

The Campbell-Thrane case studies conclude that the integrated model is superior.

> The integrated model is generally more advantageous than the nonintegrated in terms of organization, facilities, and cost

> because basic skills and vocational skills are taught to students by the same teacher in the same classroom. Additional inservice training for vocational teachers is often needed, but not extra teachers, space, or rooms. The advantages of the integrated program are distinctly greater for students, their families, and the community because it tailors basic skills instruction to jobs and because it trains more students in basic skills.

The advantages of the integrated model are considerable, but the obstacles to its implemention are significant. This approach requires structural change in existing programs. Issues of turf and incentive, and concerns about credentials must be resolved. Inevitably, questions are raised about the appropriateness of nonexperts teaching basic skills. Questions must be answered about who will develop the curriculum and what method he or she will use. All of these concerns surface in both vocational and academic education communities.

In the non-integrated model, proficiency in basic academic skills must be accomplished by academic departments or a remediation service. Using this model, schools route students with deficiencies in mathematics to the math department, in reading to the English department, or to the learning lab for extra help. In other words, the responsibility for teaching basic academic skills lies outside the vocational classroom. Such models have inherent scheduling problems that limit student participation in remediation or enrollment in additional coursework. Participating in remedial or "special" classes is undesirable to many students because of the negative image associated with the label, and because the academic subject is separated from the students' vocational interests. Despite these limitations, Campbell-Thrane observes that the nonintegrated approach is the one most commonly used for seeking improvement in vocational students' basic skills.

The combination model adds instruction in basic academic skills to the vocational program, often through team-teaching arrangements that bring academic teachers into the vocational classroom or laboratory. This combination reduces the amount of subject-matter disconnectedness and removes from the vocational student the label of remediation. However, this approach is expensive and requires cooperation and understanding between the academic and vocational programs. The combination model is based less upon a theoretical construct and more upon local decisions to adapt available resources to meet educational needs. The particular elements used in this approach will be chosen based on the local situation and may vary considerably from one program to another.

Employer Perspectives on Basic Academic Skills

> School systems appear to have underestimated the importance of basic (academic vs. vocational) skills for successful employment of students entering the work force. (Henry and Ueber Raymond, 1982)

Employers find that large numbers of employees are deficient in a wide variety of areas, including speaking, listening, reading, writing, reasoning and science skills. Collectively, these deficiencies limit workers' upward mobility and adaptability to changes in the workplace.

Vocational education offers an experiential context in which to address deficiencies in basic academic skills. But in order to proceed in this direction, vocational educators must assume responsibility for academic outcomes, and vocational students must reorient their perception that vocational education is an alternative to academics.

> Given what employers say about their needs...young people with an interest in a broad occupational area should explore work in that area as a focus for their acquisition of general knowledge and skills, rather than as a substitute for academic achievement.... (Hamilton, 1986, p. 242)

How does this exhortation for academic skills correlate with predictions that a shrinking labor force between now and the turn of the century will provide employment opportunities for the less-skilled? The Committee on Business and the Schools, a subcommittee of the Committee for Economic Development of the National Alliance of Business leadership group, Youth: 2000, provides two hypotheses in response to the labor supply/demand question:

> One hypothesis is that a reduction in the supply of labor will not do much to solve unemployment problems; that, in fact, in a free market society, the number of jobs created will be equal to the number of productively-employable people who are available in the labor force, ... and that the unemployed consist primarily of people in transition between jobs, and people who are unemployable.
>
> The second hypothesis is that any job that can be done by an illiterate can and will be done better and cheaper by a machine; therefore, illiterates are, by and large, unemployable and will remain unemployable. (Youth: 2000, A Call to Action, 1986, p.16)

Several reasons compel education institutions to link with employers in the design and delivery of basic skills programs. The 1982 Center for Public Resources study titled Basic Skills in the U.S. Workforce (Henry and Euber Raymond, 1982) indicates that perceptions held about basic skills by education leaders differ from those held by business and industry leaders. These differences include beliefs about the relative need for specific competencies, the level of attainment of competencies by graduates, and assessment of the schools' success in preparing graduates for employment:

> A majority of companies surveyed identified basic skill deficiencies in the majority of categories listed. Over 75 percent of the school systems, however, assessed the majority of graduates entering the work force as 'adequately prepared' for employment. (p. ii)
>
> It appears that the basics of the physical sciences are increasing in importance for job success as technology begins to affect virtually every factory and office job. A quarter of the responding school officials listed science as 'of little importance.' Few listed such skills as 'of great importance.' (p. iii)

Hamilton's 1986 work supports the Center for Public Resources' study:

> [B]usiness leaders, who might have been expected to urge the schools to devote public resources to equipping their future workers with specific skills, have instead called with remarkable unanimity for more rigorous academic instruction of those young people who will not enroll in higher education....(p. 240)

In order to bridge the gap between business and education, a structure must be created for involving business in education. Vocational education, with its system of program advisory boards and councils, is "program-ready."

However, we must be careful not to assume that business knows what it wants. The Center for Public Resources' study suggests as much:

> For their part, however, businesses have a hard time translating their general perceptions of basic skills deficiencies among employees into specific assessments of the nature and level of those deficiencies compared to job requirements. (Henry and Euber Raymond, 1982, p. iii)

Also, in studies of occupational literacy requirements, Mikulecky reports that employers' perceptions of work-related literacy requirements often differ substantially from those that are actually found by trained observers (Mikulecky, 1982). And Mikulecky and others have identified another business-education gap:

> Studies show that the literacy demands encountered in schools bear little resemblance to those encountered in the workplace (Mikulecky 1982). Most work-related reading involves accomplishing tasks in an endeavor that Sticht (1975) terms "reading to do." Rapid and functional "reading to do" differs from the "reading to learn" that students perform in school (Mikulecky and Winchester 1983; Mikulecky and Ehlinger 1985).

Classroom mathematics is also often divorced from application. Indeed, there may be an equivalent discrepancy in mathematics similar to that between "reading to do" and "reading to learn." The difficulty of simulating the workplace in the classroom has prompted many observers to call for increased opportunities for youth to assume work roles while in school. Hamilton, (1986) advises:

> Cooperative education, on-the-job training, and variants of experience-based career education can complement classroom learning, not simply by putting young people to work, but by placing them in a dual role as workers and learners. [See "The Varieties and Effects of Work During Adolescence" by Laurence Steinberg, in Michael Lamb, Ann Brown, and Barbara Rogoff, eds., Advances in Developmental Psychology, Vol. 3 (Hillsdale, N.J.: Erlbaum, 1983).] Educators who are committed to excellence for all students should capitalize on the current reform movement by enlisting employers and non-profit organizations to provide experiential learning designed to motivate students for academic learning. (p. 242)

However, recent legislation by states across the nation has increased the amount of "time on task" in school (Ferqueron 1984). The net effect has been to reduce or eliminate the time available for experiential learning.

Policy Implications

> The transition in employment, the changing nature of the workplace, and increasing international competition, among other factors, make it imperative to focus attention on ways to ensure that public education, including vocational education, will create a citizenry and a labor force that have the skills that are appropriate for both today and tomorrow. (Vocational Education and Economic Development in Indiana, 1987, p. 173)

Short of a complete reformation and restructuring of public education, there are things that can be done to bridge the gulf between the worlds of work and education. We propose that the Work-Education Bridge can help draw employers and educators together in a cooperative endeavor to define the basic academic skills content of jobs.

How does the process work? First, we propose that teams of vocational educators be trained to perform task analysis in the workplace. Because a vocational program may teach skills that are used in a variety of related occupations, the WEB process focuses on a sampling of those jobs that relate most closely to the specific vocational preparation. Then, based on their analyses of occupations, teachers select and devise basic skills instructional materials that closely approximate and, whenever possible, incorporate the materials, tools, and processes used on the job. In short, the students of these teachers will learn basic skills in the context of the vocation. The WEB teacher will feel greater ownership of the basic skills curriculum because he or she will be its primary author.

Piloting the WEB process took place during the summer and fall of 1987. On the basis of the pilot testing, the research team formulated plans for further dissemination of the model. Obviously, implementing the WEB process will require substantial inservice training and orientation for teachers, administrators, and employers. The experiences gleaned from a trial implementation will guide the dissemination approach.

The WEB model does not promise easy solutions to the problem of teaching basic skills in vocational education. The process is labor-intensive. The time required for a teacher to develop curriculum for one class may exceed available "preparation" time. In addition, the WEB process will not lead to products that can be marketed on a wide scale. It is a grassroots, ongoing approach to including basic academic skills in vocational education. The WEB process blurs traditional education distinctions. It advocates that vocational teachers teach academics and develop curriculum, too. The decentralized approach of the WEB model may lead to less standardization and greater diversity. In sum, the WEB process is not a "grand solution" of the type favored by hierarchical systems. The only real advantages are that students might learn and retain more, and vocational teachers might find greater satisfaction and success than under current methodologies.

What Is Basic in Vocational Education?

The WEB process will help to identify the critical academic skills for a particular occupation. However, the notion of criticality still leaves open the question, What are basic skills? We argue that regardless of the grade level assigned to academic skills that have been identified through task analysis of an occupation, if the skills are essential for successful job performance, they are basic skills.

The chapters that follow are the product of the research and literature review conducted by WEB project staff. Each chapter provides an additional response to the question: What is basic in vocational education? Readers will find that the researchers who prepared these chapters do not always concur. There are contradictions and inconsistencies among the views expressed. There is agreement, however, that basic academic skills cannot be separated from vocational education. Vocational education affords a context--possibly the best context--for teaching and learning occupationally-related basic skills.

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CHAPTER TWO

Basic Literacy and Communication Skills for Vocational Training

by

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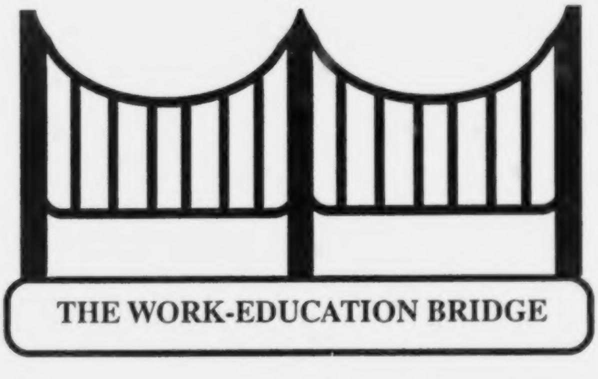
Rad A. Drew


THE WORK-EDUCATION BRIDGE

SPRING 1988

Basic Literacy and Communication Skills for Vocational Training

by
Larry Mikulecky, Ph.D.
Rad A. Drew

During the last decade, a good deal of research and opinion has become available on the level and type of basic skills required for training and participation in the workplace. This paper reviews and synthesizes recent research, giving particular attention to what is known about the literacy demands in the workplace and the abilities of various segments of the adult and adolescent population. Sections of the paper focus on what is known about the relationship of basic skills to job performance and the degree to which basic skills are generic or transferable from one setting to another. The paper concludes with an overview of effective programs and their characteristics as well as guidelines for programs, materials, and instructional development.

Defining What Is Basic

There is much discussion and disagreement in defining what is meant by the terms "basic skills," "literacy," and "illiteracy," and in defining the nature of this country's illiteracy (or low literacy) problem. Disagreement focuses on determining what constitutes literacy. If "literacy" means that an individual can sign his or her name, as it did at the turn of the century, then the majority of our country's citizens are literate. If, however, "literacy" means that an individual can gather information from complex printed material to complete a task on the job, then many people in this country are "illiterate."

Literacy is not easily defined. In a recent paper for the U.S. Office of Educational Research and Improvement, Valentine (1986) addresses issues central to definitions of literacy. He points out that much of the confusion derives from the fact that there is little agreement on what skills comprise literacy. For example, which clusters of skills comprising reading and writing are essential? One can sidestep the issue of what skills comprise reading and writing and simply look at materials that people are able or unable to read and write. This, however, creates another problem of definition: Literacy means being able to read and write which materials? Bormuth (1975) suggested that the list of materials will always differ from person to person and from situation to situation, and therefore offers the definition of literacy as "the ability to respond competently to real-world reading tasks." (p. 65) Guthrie (1983) expands on this idea by noting that the "reader's literacy depends on the context of the situation, not on a specific achievement level." (p. 669)

Some writers focus on specialized forms of literacy. Sticht (1975) differentiated externally imposed literacy tasks from internally imposed tasks and defines functional literacy as

> the possession of those literacy skills needed to perform some reading task imposed by an external agent between the reader and a goal the reader wishes to obtain.

Such definitions create new problems. Kirsch and Guthrie (1977-1978) pointed out that reading the same material (i.e., a news magazine) is functional for some people but leisure reading for others. Valentine (1986) suggested functional literacy is the area of overlap between print literacy and functional tasks. He leaves it to others to define exactly what comprises print literacy.

Rush, Moe, and Storlie (1986) refer to "occupational literacy," which they define as "the ability to competently read required work-related materials." (see **Appendix A**) They note further that

> by definition, functional literacy varies according to individual demands of divergent roles, settings and materials. Occupational literacy competencies comprise a subset of functional literacy. Required competencies vary from occupation to occupation and from job to job within occupations. (p. 1)

Some researchers and government agencies have attempted to

> define literacy by linking it to a grade level of performance. Harmon (1987) reported that researchers have variously proposed standards ranging from a fourth- to a twelfth-grade level. This search has almost become a modern-day quest for the Holy Grail. (p. 8)

Some government agencies simply use grades completed in school as a measure of literacy. Smith, Balian, Brennan, Gorringe, Jackson, and Thone (1986) indicated that the National Health Survey suggests fourth-grade completion as the measure of literacy. The Census suggests sixth-grade, and the Department of Education suggests eighth-grade completion as the threshold for the literate. Rationales are usually not discussed. The unacceptability of this sort of approach is highlighted by Kirsch and Guthrie (1977-1978), who point out that the average reading level of eighth graders in Chicago range from the 4.4 grade level in the lowest scoring school to a high of 10.5 in the school with the best score. Darling (1981) made an even stronger case by noting that of students registered for adult basic education in Jefferson County, Kentucky, the median grade completed was 8.6 but the median tested reading grade level of entering students was 2.0.

The problem of establishing a sensible grade-level indicator becomes even more problematic when the role of the reader's background is considered. Some workers can competently read work-related material that averages one to two grade levels above the difficulty level of general newspaperlike material that they can comprehend (Diehl and Mikulecky, 1980; Mikulecky, 1982). The authors attribute this seemingly higher reading ability with work reading to familiarity with the topic and format of the material. Sticht, Amijo, Weitzman, Koffman, Roberson, Chang, and Moracco (1986) present military data that indicate a range of four grade levels of tested reading ability between the reading abilities required for job-related reading by highly experienced workers and workers with no experience on the reading topic. This suggests that background knowledge can account for up to four grade levels of reading ability with a given topic and print format. Grade-level definitions of literacy levels are particularly inaccurate as readers' background knowledge increases.

The research literature is filled with attempted definitions of literacy and critiques of those definitions. The more focused the definition, the less likely it is to apply in all cases. More general definitions tend to be more accurate but not very useful. William Gray's (1956) omnibus definition seems to be as complete as any. Gray stated:

> A person is functionally literate when he has acquired the knowledge and skills in reading and writing which enable him to engage effectively in all those activities in which literacy is normally assumed in his cultural group. (p. 24)

Since literacy appears to be more in the nature of changing relationships than measurable quantities, it is unlikely that anyone will arrive at an acceptable level or criterion allowing one to accurately and usefully state the number of illiterates.

Writing about a recent study by the National Assessment of Educational Progress, Executive Director Archie E. Lapointe states:

> This study inventories the literacy skills of America's young adults, ages 21-25. By yesterday's standards the news is good: Ninety-five percent can read and understand the printed word. In terms of tomorrow's needs, there is cause for concern: Only a very small percentage can understand complex material.
>
> While we don't have a major illiteracy problem, we do need to improve the skills of most of our young adults. In other words, we do have a literacy problem. (Kirsch and Jungeblut, 1986, p. iii)

Literacy Demands in the Workplace and in Vocational Training

Two decades of civilian and military research have documented and examined the range of literacy demands in the workplace. Though there are a small and shrinking number of jobs requiring little or no literacy, the amount and complexity of literacy demands appears to be increasing in most sectors of the workplace.

Workplace Literacy Demands

Research has revealed that reading, writing, and computation in the workplace is ubiquitous and at a relatively high level. Diehl and Mikulecky (1980) examined 100 workers from a representative cross section of occupations ranging from executive vice president to forklift operator. Only two percent of occupations examined required no reading or writing. Time spent reading print, charts, graphs, and computer terminals averaged nearly two hours daily. Difficulty levels of 70 percent of the reading materials on the job ranged from ninth- to twelfth-grade levels. This finding also concurs with the work of Rush, Moe, and Storlie (1986). In addition, Sticht (1982) reports similar reading times and difficulty levels for military jobs and reading materials. Mikulecky (1982), in a comparison study of school and workplace literacy demands, found that high school juniors spent less time reading, including homework, than all categories of workers except blue-collar workers. In addition, the difficulty levels of work materials were generally as difficult or more difficult than high school materials. Students unable or unwilling to read in school, and who expect to be free of reading when they are employed, are in for a rude awakening. Most of these students will find it easier to hide from literacy in school than they will in the workplace.

In addition to fairly difficult on-the-job reading materials and training materials, many high school students are unprepared for how basic skills are used in the workplace. Most of workplace reading, writing, and computation is done to accomplish tasks and make assessments. Rather than reading from a single text, workers must gather information from several sources to solve problems, provide services, and perform tasks. Research by Mikulecky and Winchester (1983) and Mikulecky and Ehlinger (1986) have found clear evidence of a strong relationship between higher-level "metacognitive" and problem-solving reading abilities and job performance across different occupations. The ability to set purposes, self-question, summarize information, monitor comprehension, and make useful notes distinguishes superior job performers from merely adequate job performers.

A synthesis of research on workplace literacy produces several generalizations:

o Most jobs call for literacy and computation.

o Workers read a variety of materials while high school students usually do not.

o Literacy and computation on the job are necessary for performing tasks.

o Workplace literacy and computation are often social phenomena involving asking questions and gathering some information from other workers.

o Workplace literacy calls for regular use of higher-level application and metacognitive reading skills (i.e. setting purposes, self-questioning, summarizing, and monitoring), while high school reading is predominantly fact gathering.

Literacy Demands in Vocational Training

Though workplace literacy demands are high, the vocational training literacy demands are even higher. Rush, Moe, and Storlie (1986), Sticht (1975), and Mikulecky (1982) found that reading was a daily requirement of students in training courses and in the workplace. Mikulecky (1982) found that students in vocational training programs actually spent more time reading texts and manuals than did high school juniors (135 minutes daily versus 97 minutes daily).

Rush, Moe, and Storlie (1986) studied training program courses for 10 occupations. They found that student reading time ranged from 42 minutes to six hours per day, depending on the occupation. They also found that students in training programs used primarily reading-to-learn strategies, and that textbooks, reference books, and sets of complex instruction were part of the daily required reading. Students often encountered information in book-length and graphic formats as well as shorter materials (e.g., quizzes, instruction sets, chalkboard notes) in combinations of text and graphic formats in the classroom and laboratory.

In addition, Rush, Moe, and Storlie observed that the reading requirements were varied and ranged from informal notes in the classroom, to highly technical prose in textbooks. Specialized vocabulary--both true technical words and common words with special occupational meanings--was present in reading materials and was encountered in each of these types of reading. Rush, Moe, and Storlie also studied job training materials to find how easily understood or readable they were. Readability formulas indicated that training materials ranged in difficulty from the eighth-grade to the college-graduate level. The authors point out that the high reading levels of materials are an additional demand on the learner, but that they are sometimes partially offset by the students' interest, motivation and familiarity with a given subject matter.

Given the amount of reading required in both training and work settings, and the highly demanding printed material students are required to read, it is clear that an individual's success in the classroom and the workplace is dependent, in part, on an ability to read and apply information obtained from complex textual and graphic materials. More than simply reading for facts is required both of workers and of students in training programs. Basic skills in vocational training and in work settings include reading to solve problems and to make judgments.

Increases in Basic Skills Demands

Each major war during this century has brought with it increased literacy demands for military performance. During World War II, the U.S. Army set a minimum of a fourth-grade reading level for acceptance into its ranks. A special 1947 census defined literacy as five years of schooling, and found 13.5 percent of the population illiterate. By the 1960s, the U.S. Office of Education had raised the measure of literacy to eight years of schooling. Even this level was considered too low in the 1970s when the Adult Performance Level Study was released (Cook, 1977).

During the late 1970s, a survey of citizens in Milwaukee reported the types of materials residents considered essential to normal functioning. These materials provide a reasonable idea of what current functional literacy means to a cross section of adults. Though these materials were not specific to the workplace, the complexity and difficulty levels of these materials parallel the complexity and difficulty levels of materials other researchers have found in the workplace (Mikulecky, 1982; Rush, Moe and Storlie, 1986). Frequently mentioned materials in the Milwaukee study included relatively simple items such as street and traffic signs, and medicine bottle directions, to more complex items such as bank statements, health and safety pamphlets, loan applications, and product warning and antidote directions. Difficulty levels of the more complex safety instructions and economic statements were at the twelfth-grade level and higher (Negin and Krugler, 1980).

Current estimates of occupational demands for literacy indicate that over 90 percent of occupations call for some reading and writing (Diehl and Mikulecky, 1980; Mikulecky, 1982). This is up from less than 10 percent in the first decennial census conducted in 1790 (Tyler, 1978).

The difficulty levels of occupational reading are quite high. Nearly every civilian and military study cited above sets occupational reading levels at the high school level or above. Even blue-collar workers average more than 1-1/2 hours of daily job-related reading. Though having a wealth of background knowledge on a topic can tend to effectively lower reading difficulty levels, the most heavy job-related reading is performed by new workers learning new jobs (Kern, 1980). New workers are the least likely to have a wealth of background experience. This heavy reading expected of new workers is a dramatic change from earlier times when one out of 10 workers performed the literacy tasks for others.

There are a few exceptions to the general trend of higher literacy requirements in the workplace. For example, some low-paying jobs can be simplified through fragmentation and automation. In West Germany, cost-effectiveness has resulted by breaking down complex tasks to simple tasks done repeatedly by an individual worker. This method is not as cost-effective as having a worker who is literate and can adjust flexibly to new tasks when the operation for which he or she has been trained is temporarily halted. However, fragmentation can be cost-effective if the worker is paid an extremely low wage, as are the immigrant "guest workers" in West German industries. In the United States, where no legal guest-worker option exists, fragmented jobs tend to be shipped out of the country leaving Americans with low literacy abilities without employment. Some fast-food chains in the United States have eliminated the need for much literacy among employees by using pictures on cash register keys and computerized pricing.

A trained manager must be knowledgeable and available in the event of equipment difficulties, but the system works as long as less-capable workers can accept extremely low pay for their severely limited performances. Similar approaches are being used in the automating of oil-pipeline monitoring gauges and holographic package readers in grocery stores. The grocery store example is useful for examining this low-skill job trend. Fewer mistakes and delays in ringing up purchases mean faster lines and therefore the need for fewer low-paid check-out personnel and packaging personnel to run and check prices. Computerized inventories also lower the need for massive warehousing and many of the warehouse jobs associated with such massive operations. Several middle-skilled-level jobs are created for building, marketing, and servicing the holographic price readers (Harste and Mikulecky, 1984).

Problems Related to High Basic Skill Demands

In the early 1980s, there were several indications from industry that the education levels of new and existing workers were inadequate. According to a 1982 Center for Public Resources survey,

> over 65% net of responding companies note that basic skill deficiencies limit the job advancement of their high school graduate employees, and 73% responded that deficiencies inhibit the advancement on non-graduates. (Henry and Raymond, 1982, p. 23)

Percentages of basic skills difficulties reported by employers in the survey were the following:

30 percent-	Secretaries having difficulty reading at the level required by the job.
50 percent-	Managers and supervisors unable to write paragraphs free of mechanical errors.
50 percent-	Skilled and semi-skilled employees including bookkeepers unable to use decimals and fractions in math problems.

The Wall Street Journal cited industry reports that indicate increased economic problems resulting from workers who are unable to meet the basic skills demands of their jobs. William Barnes, vice president of finance of JLG Industries, reported that "poorly educated workers are our no. 1 problem, the main factor slowing our growth." (Hymowitz, 1981, p. 1) JLG reported having spent over $1 million to correct worker literacy mistakes. Similarly, Mutual of New York reported "an estimated 70 percent of the insurance firm's correspondence must be corrected or retyped at least once." Concerns regarding the safety of workers who cannot read warnings and follow written directions have been issues in a growing number of court cases and have led to several firings at Westinghouse Electric Corporation's defense gear plant in Sunnyvale, California.

In many industries, workers with low basic skills are being replaced. For example, following the lead of the Japanese, U.S. employers in the auto industry have substantially replaced unskilled workers with robots. In 1981, General Motors reported one skilled worker in every 5.6 assembly-line workers. By the late 1980s, General Motors was approaching it's goal of a 1-1 ratio of skilled and nonskilled workers (i.e. an 80 percent reduction in nonskilled positions).

The Changing Nature of Work

One indication of the changes in literacy skills required to participate in society is the changing nature of work in the United States and other industrialized countries. As new jobs are created and old jobs disappear, new levels and types of basic skills for employment are also created. U.S. Department of Labor projections of occupational areas experiencing the biggest growth include service workers, psychiatric aides, dental assistants, claims clerks, secretaries, and salesclerks. Among jobs experiencing large declines in the number of openings (13 percent to 20 percent) are farm laborers and tenants, logging workers, housekeepers, maids, and home child-care workers. These low- literacy skill jobs are decreasing. In addition, many other nonskilled production jobs are being moved overseas where nonskilled workers perform tasks for considerably lower salaries than do Americans. Several occupations have been projected for the greatest growth by the Bureau of Labor Statistics:

- industrial robot production,
- geriatric social work,
- energy technician,
- industrial laser processing,
- on-line emergency medical, and
- genetic engineering.

These projections show that it will be increasingly difficult for workers to find adequate employment in jobs that require a low level of literacy skills.

Department of Labor data do not suggest that all new jobs will involve high technology such as lasers or robots and require years of specialized training. Rumberger (1984) reports that the greatest number of new jobs are unrelated to high technology. Between 1978 and 1990, the United States will need 672,000 new janitors and sextons but only 199,000 new computer systems analysts. These janitorial positions, however, usually require the ability to read manuals, understand the directions on chemical solvents, handle new equipment, and do a good deal more than simply sweep floors.

Though years of training will not be required for all new jobs, it is likely that higher minimum levels of basic skills will be required. The growing service industries require a good deal more paperwork and regular managing of information to solve problems than did higher-paying "muscle work" production industries.

Future Workplace Training Demands

A virtual consensus exists among researchers, educational administrators, and vocational and technical education directors that the practice of life-long learning is essential to success for today's workers. In A Future of Learning and Work, the Indiana Economic Development Council (1987) summed up this common attitude:

> Due to rapid economic, social, and technological change, all workers will need to be flexible and to develop strong learning skills so that they may readily adapt to changing job requirements. The distinction between learning and working is increasingly blurred.... More and more, working means learning. (p. 1)

James Bishop, of the National Center for Research in Vocational Education, also notes that for success on the job:

> Some employers do mention skills such as blueprint reading, but the more traditional definition would be learning ability--being able to learn things fast. The key is communication abilities--reading, writing, listening, and speaking.... The other is reasoning abilities. (Miguel, 1985, p. 33)

At a recent University of Minnesota conference on the training, retraining, and productivity of workers, Park (1984) summarized observations of vocational educators and employers. Park noted that:

> o The workforce is currently undergoing significant change. The need for training and job retraining has never been greater.
>
> o Estimates show that 90 percent of the workforce of 1990 is currently in the workforce. The figure for the year 2000 is 80 percent.
>
> o Adults must be able to adapt and adjust ... and be able to keep on learning. (p. 11)

Other researchers note that in the future workers will be more likely to change jobs several times and will require regular retraining and continuing education. Dr. Rob Melnick, vice president of the Hudson Institute and director of Hudson's Center for Education and Employment Policy, expressed this judgment in a recent interview:

> The best prepared worker for the future will be one who has both strong "learn-how-to-learn" skill and a sense of the specific skills and attitudes required in an occupation. (p. 2)

Aside from the lifelong-learning generalization, there is less agreement about which skills will be needed in the future. For example, Rumberger (1984) maintains that there is no evidence to support the "myth" that high technology will be the primary source of new jobs in our economy in the future. Instead, he contends

> Most new jobs will not be in high-tech fields in the future economy, and technology will not require a vast upgrading of workers' skills, because the primary impact of technology will be to reduce the skill requirements of jobs. (p. 1)

Others (Mikulecky, 1984; Stitch and Mikulecky, 1984; Rush, Moe, and Storlie, 1986) maintain that though it is true that high-tech jobs will only make up a small percentage of future jobs, jobs that have traditionally required minimal basic skills are becoming more complex, demanding higher-level reading, writing, and computational skills. Some jobs will show a decrease in skill requirements, but most jobs will move from low-skill to middle-skill levels.

Changing Demographics and Abilities

Though there is some disagreement about the degree of increased literacy demand for different occupations, nearly everyone recognizes that there has been some increase in demands. In addition, demographic, educational, and occupational changes exacerbate and complicate the problem of increased literacy demands. Because there are fewer young people available for entry-level jobs and the military, employers are faced with less literate new workers at the same time that job literacy demands are increasing.

Decline in Youth Population

Some demographic projections are relatively safe to make. For example, barring any unforeseen catastrophe, it is possible to predict with a high degree of accuracy the number of young, newly-trained persons likely to be available for employment during the next few decades. That is, everyone who will be 20 years old by the year 2000 has already been born.

According to the 1983 U.S. Bureau of Census data, the United States has recently reached the peak of a 20-year growth in the number of young adults (18- to 24-year-olds) available for employment. In 1981, more than 30 million individuals were in this age group. By 1995, there will be only 24 million people between age 18 and 24 in the United States. This is a projected decline of 22 percent in less than a decade and a half. The cohort of 18- to 24-year-olds who do not go to college forms the pool of what is generally called entry-level workers. It is from this group that the majority of workers in American industry and the military are drawn. In the 1930s and 1940s, between 10 percent and 15 percent of 17- and 18-year-olds went on to higher education (Grant and Lind, 1979), leaving over 85 percent of the remaining population available for entry-level work. Many of these individuals who did not seek a college education were highly intelligent and self-taught. The more competent of this group were "creamed off" for positions of some responsibility as skilled blue-collar and service workers in thousands of workplaces. In many cases, these intelligent, competent, non-college graduates were the ones who made sure things worked.

The nation no longer has 85 percent of the youth population from which to draw in filling entry-level jobs. According to Lisack (1984), director of the Office of Manpower Studies at Purdue University, the national percentage of high school graduates who go on to college is now 56 percent, with less than half of the shrinking 18- to 24-year-old population available for entry-level work. For the most part, the 44 percent of those electing not to go to college are less competent in terms of basic skills than the 56 percent who do. Sticht (1982) reports that the contingent of individuals available for military enlistment averages only an eighth-grade reading level ability. Many, of course, are below this level. In the civilian sector, this non-college graduate contingent is applying for entry-level positions in industry, retail, service, and clerical work. The number from this group available for "creaming off" is likely to be considerably less than in previous decades.

Alice Bird McCord, personnel vice-president of the National Retail Merchants Association in New York City, notes another aspect of the phenomenon of competent workers moving out of traditional occupations. In Business Week she comments that it is a decidedly different labor market today than it was 15 or 20 years ago:

> The kind of well-educated housewife who formerly took a part-time minimum wage job in a department store then is probably a full-time careerist now, leaving the lower-level job to the less well equipped. ("How Business Is Joining," 1984, p. 98)

Who Can and Cannot Meet Occupational Basic Skill Demands

Several national assessments of adult and adolescent abilities have been performed during the 1970s and 1980s. Though none of these studies directly addressed workplace literacy abilities, several items in each of these studies can allow us to draw inferences about proportions of the population likely to experience difficulty with basic skill requirements in the workplace and in vocational training.

Usually, the Adult Performance Level study (Northcutt, 1975) is used to provide estimates of the number of millions of illiterate adults. A more helpful use of the data from this study of adult reading abilities is to examine the tasks presented to adults and the percentages of adults who could not successfully complete those tasks. Items listed below are from the Northcutt (1975) study and resemble the types of basic skills tasks several researchers have observed in the workplace. Of the cross section of adults in the study:

- 60 percent did not accurately calculate from advertisements price differences between new and used appliances
- 44 percent did not successfully match want ad job requirements to personal qualifications
- 40 percent did not accurately determine correct change given a cash register receipt and the denomination of a bill
- 36 percent did not enter the correct number of tax exemptions on a W4 form
- 26 percent did not determine if their paycheck was correct
- 24 percent did not write their own correct return address on a letter
- 22 percent did not address a letter to ensure it would arrive at its destination
- 20 percent did not comprehend an equal opportunity announcement
- 20 percent did not write a check that would be accurately processed by a bank

The general magnitude of the Northcutt results was supported by other major functional literacy studies of the 1970s. These included the Survival Literacy Study (Louis Harris and Associates, 1970), the Adult Functional Reading Study (Murphy, 1975), the Mini-Assessment of Functional Literacy (Gadway and Wilson, 1975), and military reports from Project REALISTIC (Sticht, Caylor, Fox, Hauke, James, Snyder, and Kern, 1972).

In 1986 the NAEP released a major study of the functional literacy abilities of 21- to 25-year-old young adults (Kirsch and Jungeblut, 1986). This study selected items from previous educational studies as well as designed items based on what research indicated were reading tasks encountered by a substantial proportion of adults. More than 3,600 randomly selected adults were tested in their homes by more than 500 trained interviewers. The result is a study which is the most accurate estimation available of what young adults can capably read. In addition, selection of items from previous measures allows comparison of the performance of these adults to the performance of other individuals on other tests.

The items and results of this study are categorized and presented in terms of three types of literacy: prose, document, and quantitative. Prose literacy involves understanding and using information from texts (e.g., reference manuals, assembly instructions, maintenance procedures). Document literacy involves locating and using information in documents (e.g., job applications, payroll forms, schedules, maps, tables, indexes). Quantitative literacy involves applying arithmetic operations to information embedded in printed materials (e.g., computing inventory, figuring a tip, completing an order form, determining the amount of loan interest from an advertisement).

Not all subjects attempted all the test items. An extremely simple pre-test eliminated from full testing subjects judged to have such limited literacy skills that the literacy simulation tasks in the test would unduly frustrate and embarrass them. About 2 percent of the young adult population was estimated to be at this level. Between half of a percent and one percent of the total population reported being unable to speak English.

Like the APL study, the NAEP study did not directly address workplace basic skill demands. Some items from the NAEP study, however, closely resemble workplace literacy demands and provide a sense of what proportion of the population can and cannot meet those demands. The NAEP results paint a picture of large percentages of the adult population having difficulty with the sorts of basic skill demands present in many lower- and middle-level jobs.

A few observations about the results are in order. When viewing percentages of the total 21- to 25-year-old population, it appears that there is not a large degree of basic illiteracy. Over 95 percent of young adults can

o sign their names

o locate the expiration date on a driver's license

o locate a time on a meeting form

o enter a caller's number on a phone message form

o write about a job they would like to hold

o enter personal information on a job application

For slightly more complex tasks, however, there is a much lower percentage of young adults able to meet basic skill demands. For example, about 70 percent of young adults can

o write a letter stating that an error was made in billing

o use an index from an almanac or manual

o enter and calculate bank balances

o determine eligibility from a table of employee benefits

Only 10 percent to 40 percent of young adults were able to perform complicated, multi-step occupational literacy tasks, such as

o orally interpret distinctions between two types of employee benefits

o use schedules of departures and arrivals

o plan travel arrangements using flight schedules

- o calculate and total costs from catalogues

In short, the sorts of tasks associated with growing service and technical occupations are the sorts of tasks that significant numbers of young adults were unable to successfully perform.

Racial and Ethnic Disparities in Performance

The reported performance of young adults can be somewhat deceptive since the totals are for average performance. The NAEP study did not report data by socioeconomic status, but it did report data by racial and ethnic groups. In urban areas and vocational programs that serve significant numbers of learners who are minority group members or poor, the picture is worse.

There are significant differences in abilities between the various racial and ethnic groups as reflected in the data on young adults. The data indicate that it is probable that 98 percent of whites could fill in a job application while only 82 percent of blacks and 92 percent of Hispanics would be able to successfully complete the same task. Though a vast majority of all ethnic populations can accomplish basic literacy tasks, gaps in populations become wider as the complexity of tasks increases. For example, it is probable that 22 percent of whites would have difficulty writing a letter to state that an error was made in billing. On the same item, 60 percent of blacks and 42 percent of Hispanics would be likely to have difficulty. Test data indicate that it is probable that 35 percent of whites would have difficulty following directions to travel from one location to another using a map. On the same item, 80 percent of blacks and 63 percent of Hispanics would be likely to have difficulty. Items at slightly higher levels are extremely difficult for all populations. For example, an item on the prose scale asks individuals to orally interpret distinctions between two types of employee benefits. Nearly 90 percent of whites, 99 percent of blacks, and 97 percent of Hispanics would be likely to experience difficulty with this literacy task. Comparable percentages of all populations would be likely to experience difficulty calculating and totaling costs based on item costs from a catalogue.

The young adults who were tested using NAEP simulations of functional literacy tasks also responded to items included in an earlier NAEP school literacy assessment. This allows a comparison between the performances of students in grades four, eight, and 11 and the performances of young adults. The data indicate that only about 6 percent of the young adult population read below the fourth-grade level, but 20 percent read below an eighth-grade level and nearly 40 percent read below an 11th-grade level. These totals are somewhat deceptive, however, due to wide racial and ethnic disparities. Nearly 18 percent of black young adults read below a fourth-grade level, close to half read below an eighth-grade level, and more than two-thirds read below an 11th-grade level. Hispanic young adults perform somewhat better than blacks, but nearly 30 percent read below an eighth-grade level and close to one-half read below an 11th-grade level.

Substantial numbers of young adults, especially blacks and Hispanics, are ill-equipped for the already high and ever-increasing literacy demands encountered in most jobs and daily living situations. For members of these groups to be productive and self-sufficient in our society, appropriate intervention strategies will need to be implemented.

In a study to identify major trends and events that could influence vocational education in the '80s, Lewis and Russell (1980) make this observation:

> Educationally disadvantaged groups will comprise a larger percentage of vocational education enrollment. ...This implies a complementary program of remedial basic skills courses along with the regular vocational/occupational skills course. (p. 150)

Given the significantly large number of disadvantaged youth and young adults currently unable to meet the basic skills requirements of most jobs, vocational educators face a major challenge.

Relationship of Basic Skills to Job Performance

An underlying assumption behind concern about basic skills levels in the workplace is that job performance is related to workers' basic skill levels. The research suggests that there is a relationship but that it is by no means overwhelming or direct.

Most research about the relationship of literacy to job performance is sketchy and based upon information obtained from military studies. Kulp (1974), in a controlled study, found that performance of an assembly task decreased significantly when worker reading skills were more than two grade levels below the difficulty level of instructions.

Sticht (1975), in Reading for Working, reports correlations of reading ability to job sample performance that range from r=.26 to r=.37. These correlations are significant but only explain from 8 percent to 13 percent of the job performance variance. A good deal more than basic reading ability as measured by a reading test is needed to explain job performance ability. Sticht's (1982) review of basic skills training in the military notes that

> the most highly skilled, non-high school graduates in one study had a job success rate equal to those having the lowest basic skill levels among high school graduates. Thus basic skills competence per se does not appear to be the overriding determinant of success in the military. (p. vii)

By way of contrast, Hunter and Hunter (1984) meta-analyzed the results of hundreds of studies designed to predict job performance and found reading ability to be a significant predictor of job performance. Though Hunter and Hunter did not directly address basic skills tests, they did include tests of reading ability in the general category of "cognitive measures." Hunter and Hunter claim that cognitive measures tend to correlate at the r =.5 to r =.6 level (25 percent to 36 percent shared variance) with job performance. This is not a sure estimate, but research suggests it is a better estimate than many other commonly used predictors of job performance. In every job family, without exception, cognitive measures were far superior predictors of job performance than either perceptual or motor abilities. Indeed, cognitive measures were more effective predictors of job performance than biographical inventories, biographical interviews, expert recommendations, or the amount of previous education.

More recent research has attempted to identify how reading abilities interact with job performance. In two testing and observational studies of the relationship between performance and literacy abilities among nurses (Mikulecky and Winchester, 1983) and among electronic technicians (Mikulecky and Ehlinger, 1986), the researchers noted a low-level relationship between simple, literal-level reading ability and job performance. A much higher relationship was noted, however, between job performance and the ability to apply and use reading, writing, and computation skills critically. This same call for higher-level use of basic skills may explain the high relationship between "cognitive measures" of ability and job performance presented by Hunter and Hunter (1984).

The survey by the Center for Public Resources (Henry and Raymond, 1982) takes a different perspective on the role of basic skills and job performance. Survey respondents were not as concerned about overall correlations between general basic-skills levels and performance as they were about costly one-time mistakes resulting from low basic skills. Examples cited include workers accidentally killed because of inability to read warning signs, costly mistakes made because of inability to comprehend correspondence, and time lost due to the need to give regular lectures on the use of equipment as opposed to step-by-step written instructions (p. 18). Low ability levels in applied computation and measurement, according to respondents, regularly accounted for losses in production, quality, and general corporate performance (p. 20).

To summarize, literacy skills do appear to be related to job performance in at least two ways. Reading ability, as indicated by higher-level problem-solving and metacognitive skills rather that factual-level reading ability, appears to be a significant predictor of overall job performance. In addition, extremely low-level basic skills appear to be related to costly and dangerous mistakes in the workplace. The best workers can communicate and use print to solve problems. The least effective workers do not use print in such ways and may be prone to costly, dangerous errors in situations calling for the use of basic skills.

How Generic and Transferable Are Basic Skills?

It has been clear for quite some time that increased basic skills training is a requirement of good vocational training. What has not been as clear is how to most cost-effectively provide such training. During the 1970s and early 1980s, experts had limited knowledge of how to most effectively design programs to incorporate basic skills into vocational training. The usual procedure was to send students to remedial programs to get better at reading, computation, and whatever else they needed. The assumption was that once the "basics" had been learned, they could easily transfer to the workplace or vocational training. A major challenge for this approach was determining exactly what was basic. Determining key competencies and devising curricula were thus central tasks. A second line of thought noted that people tended to learn better when the basics were integrated with actual job training, and that "school work" did not seem to transfer very well to actual workplace applications. Researchers even questioned the assumption that there were "generic" transferable skills. Instead, some researchers concluded that people learned what they are taught and not a lot more.

Researchers from each school of thought share the goal of improving the basic skills competence of vocational students. Research has begun to accumulate which partially supports the assumptions of each position. For example, analyses of the documents and observations of workers from several occupations reveal many seemingly shared skills that cross occupational lines.

On the other hand, there appear to be considerable limitations on the degree to which reading learned in one setting can easily be transferred to other settings (e.g., reading a story or a workbook is of little help in reading a manual or following a trouble-shooting guide).

Evidence for Generic Skills

Researchers who hold that some basic skills may be "generic" try to determine those skills by interviewing vocational instructors and examining the documents and tasks faced in training and on the job. Greenan (1983, 1982), Greenan and Smith (1981), Kawula and Smith (1975), and Sjogren (1977) have examined occupation descriptions, interviewed experts, and analyzed training and work materials to search for similarities across occupations. They have generally concluded that there are five skills areas which appear highly generalizable: mathematics, communications, interpersonal relations, reasoning and manipulative skills. Greenan's (1983a) recent work is among the most thorough in this area. He holds the view that:

> Skills knowledge, and attitudes involved in vocational training programs and employment settings are learned behaviors and are all potentially generalizable. (p. 1)

Greenan set out to draw up a "single, definitive, and agreed upon list" of generalizable skills. In a study carefully controlled for reliability of instrumentation used for data collection, Greenan surveyed nearly 600 teachers from 32 area vocational centers. A "Generalizable Skills Importance Questionnaire" asked secondary vocational teachers which skills they perceived to be most important in determining student success in respective programs. Greenan's research revealed

> a core of mathematics, communications, interpersonal relations, and reasoning skills which are generalizable within and across secondary agricultural; business, marketing, and management; health; home economics; and industrial occupations training programs. (p. 7)

Based on his findings, Greenan was able to construct a matrix of more than 70 jobs and 115 skills. The skills are coded to show whether there is a high, medium, or low generalizability from one occupation to another. It is important to note here that, for Greenan, generalizability refers to observed presence of labeled skills across several occupations. It is not based on evidence that a skill learned in one area by a student will actually transfer and be of use in a new area. Greenan noted that

> the expectation is that the results of this study will provide vocational teachers, administrators, counselors, and other school personnel with information regarding the generalizable skills requirements in vocational training programs. (p. 8)

Greenan's assumption is that the skills will transfer and that knowing about clusters of observed skills will aid curriculum planners.

Problems of Transfer

Other researchers have focused directly on what learners are able to retain and transfer from one setting to another. Even though "experts" note similarities across occupational and school settings, these researchers have found transfer on the part of learners to be severely limited. They observe that one problem with the generalizable skills approach is that skills differ so much from task to task. A skill used one way for one task, may be used differently to complete a similar task in a different job context. For example, Duffy (1985) writes:

> To the extent that the newspaper and the job manual have different subject matter (the concepts discussed), different information access or referencing systems, and different writing styles and information display strategies, there will indeed be little transfer. If we consider how the function of graphics differs between a technical manual and a newspaper, we find that strategies one might teach for using graphics to understand (or find information in) a newspaper might even hinder (produce negative transfer) effective use of technical manuals.... The point is that reading is not a unitary concept. Transfer from one reading task to another depends on the similarity of the components -- the processing requirements -- of the tasks. If instruction in reading the technical manual does not transfer to reading the newspaper, literacy instruction based on the newspaper would probably not transfer to the technical manuals (and reading the technical manuals is, indeed, the goal of the instruction). (pp. 449-450)

Mikulecky and Ehlinger (1986) also point out problems related to skills transfer from classroom to workplace. The differences between job literacy and school literacy may explain, in part, the disturbing phenomenon of limited transfer from gains in the general school literacy abilities to comparable gains in the workplace.

Much schooling is based, both consciously and unconsciously, on the assumption that basic learnings and skills easily transfer from one situation to another. In school, student reading is largely limited to a relatively small amount of textbook reading (Mikulecky, 1982; Smith and Feathers, 1983). Only 3 percent of student writing is as long as a paragraph in length and the majority of writing is in response to text or worksheet questions (Applebee, 1981). It is generally assumed that students who perform such school literacy activities adequately will transfer their abilities and be prepared for literacy demands outside of school.

Research results on the transferability of training challenge these assumptions, however. For example, military research indicates that recruits given traditional basic skills training make gains while in class but tend to revert and lose their skills within eight weeks (Sticht, 1982a). Specific job-related literacy and computational skills programs are exceptions to this pattern. For example, Sticht (1982a) reports that

> personnel retained 80% of their end-of-course gain in job literacy training, and only 40% of their end-of-course gain in general reading. (p. 40)

Most recently Kirsch and Jungeblut (1986) report limited correlations between individuals' abilities to read prose, documents and forms, and material calling for use of computation. Test scores for these different reading tasks tend to correlate at the r = .5 level. This suggests about 25 percent shared variance among tasks. It may indeed be that there is some transfer or generalizability of skills but that it is limited to only about 25 percent. The rest of performance ability may be explained by background knowledge, experience, general intelligence, and a host of other factors.

Conclusion

Until more evidence accumulates on the degree of transfer and which skills are generic and to what extent, caution is in order. It is useful to know similarities across occupations, but evidence suggests it is not safe to assume that observed similarities imply transfer of training. Indeed, the most effective vocational basic skills training programs appear to integrate basic skills training with actual job training thereby avoiding the risk of mistakenly assuming transfer or mistakenly counting on generic skills.

Effective Training Programs

A number of successful basic skills programs in the military employ a job-oriented approach to training personnel. One of the first to apply a functional literacy approach using reading materials found in the workplace was the U.S. Army Functional Literacy Training (FLIT) program, which found occupation-specific approaches using actual job materials to be successful (Sticht, 1975, 1982).

The FLIT program developed materials based on the results of interviews with military personnel who were asked to identify the reading tasks performed on the job in the last 48 hours. Teaching materials were developed using the tables of contents, indexes, tables and graphs, forms, procedural information, etc, that were needed to perform on the job. Evaluation data (Sticht, 1982a) for more than 700 students showed that:

o Students made three times the improvement in job-related reading as in general reading, indicating that they were learning what was being taught.

o Students in the FLIT program performed three times better than comparable students in other Army and Air Force programs, indicating that general literacy training does not make as much impact on job-related reading as does job-related reading training.

o Retention studies indicated that eight weeks after FLIT training, personnel retained 80 percent of their end-of-course gain in job-related reading but only 40 percent of their end-of-course gain in general reading.

o Many students in the FLIT program made little gain and failed to master or even attempt some instructional modules and activities, suggesting the need for a longer period of development for some Army personnel.

Another highly successful military program is the Navy's Job Oriented Basic Skills (JOBS) program, the military's first attempt to apply the FLIT'S functional literacy development principles to basic skills in preparation for highly technical jobs. The JOBS objective is to provide instruction "that would enable lower aptitude personnel to increase their mastery of selected basic skills and knowledges enough to permit them to enter and complete" apprentice-level training (Duffy, 1985).

The Army's FLIT curriculum has been described by Duffy as an "exemplary program" (Duffy, 1985), and has been a model for developing other programs in the Navy, Air Force, Marines and National Guard. An occupation-specific approach has been applied to more highly technical areas, such as the Navy's JOBS program described above. Other programs include the Army's BSEP I and II, as well as its comprehensive basic skills curriculum, JSEP I and II. The Air

Force's Job Oriented Basic Skills Assessment and Enhancement System and the Army's STARS program both have been developed with an occupation-specific approach that requires students to read job-related materials and solve problems in simulated workplaces. STARS employs video-disc technology and makes the learner a member of a space team with a number of tasks to perform. Students are required to read written instructions from notes and warnings on the wall, follow directions, and monitor supplies. The program uses student responses to assess skill levels and branch to the appropriate levels on the video disc.

Other basic skills programs that apply the functional literacy approach to teaching and integrating basic skills have been developed in the public/private sector (Mikulecky, 1986; Sticht and Mikulecky, 1984). For example, a joint public/private venture trained people who were CETA-eligible to become word-processing operators in a program that integrated basic skills training with job training and used performance levels of employed word-processor operators as criteria for program completion. Training applicants were carefully recruited and screened, with special emphasis placed on selecting individuals who were not only CETA eligible but who were also likely to succeed. Classes of 30 to 35 trainees were accepted into the program. These individuals were paid to attend training 40 hours per week. Each day included language training, typing and word processing training, work habits training, and individual study time. Three full-time teachers (a reading specialist, a word-processing specialist, and a business specialist) worked with students throughout the day and planned assignments that integrate language and machine skills. Much of the classroom work simulated actual job demands: Students composed business communication that other students edited and later produced in final form on word-processing equipment. A good deal of the work involved using actual business communication that was handwritten in rough draft with editing notations.

The most clear-cut differences between this program and traditional basic skills programs related to the application and integration of training. Trainees actually used up-to-date word processing equipment and were aware of the industry standards they had to meet. Their training in language, work habits, and machine use was integrated so that their practice focused on meeting those standards. Unlike much current schooling, the cooperative program assumed no guaranteed transfer of basic skills training; instead the program used job simulation as a major training device.

The time needed for trainees to reach job-level competence varied. The fastest trainees were able to find employment within 14 weeks after training. The average time needed for the screened applicants to reach the preset standards was 20 weeks, and a few trainees took nearly 28 weeks. In spite of economic difficulties that adversely affected hiring in the area, slightly more than 70 percent of trainees found word-processing positions within six months after completing the program.

Another successful program integrating basic skills and job training (Mikulecky, 1986) involved the retraining of workers for the new basic skills and technical demands of a job that was changing. An urban municipality had recently opened a new wastewater treatment plant as a result of new clear water guidelines. The plant incorporated several technical innovations, and workers who needed little technical training to work in the old treatment plant now faced an entirely different situation. Before workers could be transferred to the new plant, they needed to be retrained in how the new process and equipment functioned, what safety precautions to use when working with a variety of dangerous gases, and how to maintain the microorganisms essential to the wastewater treatment.

An engineering consulting firm set up a cooperative relationship with a university consultant and hired a university-trained reading specialist to develop a basic skills component for the retraining program. The major academic goal was to help trainees gain mastery of technical vocabulary, concepts, and materials. The reading specialist set up special study guides to break down assignments into manageable tasks, and in some cases rewrote or redesigned training materials to lower difficulty levels. By working cooperatively with the reading specialist, teachers made modifications to traditional reading assignments and introduced key vocabulary prior to making those assignments.

The basic skills component of the retraining program can be judged a success by several standards. Nearly half the students who took special basic skills training passed their technical class post-tests. It was the consensus of both technical instructors and of the reading specialist that fewer than 5 percent of these students would have passed without the special attention they received. Of the students who attended sessions, 70 percent were able to summarize materials in their own words by the end of training. Retention of students receiving special basic skills training was actually higher than that of students who only attended technical classes. Gains in general reading ability were less encouraging. Only about 10 percent of the students taking special training made noticeable gains in their ability to read general material or new material for which they had received no direction or purpose provided by the teacher. According to the reading specialist, students making the most significant gains in job and general reading ability invested five or more hours per week in outside reading at an appropriate difficulty level.

Characteristics of Effective Programs

There are several conclusions suggested by the civilian case studies, and military programs. It does appear possible to make fairly rapid gains in the ability to comprehend technical material if training is focused on that material. General literacy improvement, however, was not a noticeable, direct by-product of any programs but did occur with sufficient time on task (five hours per week) in the wastewater treatment program with appropriate general material. Best results seemed to occur when basic skills training was integrated with technical training. Training that employed job simulations and literacy applications increased trainee time on task. In the civilian programs, actively involved students received up to three times more practice per paid day than did traditionally trained students. The integrated program, therefore, is also more attractive from a cost-effectiveness perspective.

Probably the most significant conclusion to be drawn from programs in the private sector is that successful technical and basic skills training programs are beginning to emerge in the vacuum left unfilled by traditional schooling. Where schools are unwilling or unable to match basic skills training and materials to specific occupational needs, private consulting firms are successfully filling the gap. They are successful to the degree that they do not assume transfer from general basic skills training to specific job training. Matching training to the application required on the job appears to be key.

Guidelines for Developing Occupationally Related Basic Skills Programs

As indicated earlier, there is a considerable gap between literacy demands encountered in schools and those encountered in the workplace. Students usually read textbooks to answer end-of-chapter questions. Workers tend to use printed information in conjunction with other resources present in the environment (i.e., asking questions and listening to fellow workers, background knowledge from experience, etc.) to solve problems on the job.

The problem of analyzing literacy demands and abilities in the workplace is, thus, a good deal more complicated than analyzing the same demands and abilities in schools. In schools, where most reading is "reading to learn" from textbooks, one can determine material difficulty using a variety of readability formulas and methods of discourse analysis. Reading comprehension can be assessed using an even wider variety of formal and informal reading ability measures (Farr, 1969; Pikulski and Shanahan, 1982). Similarly, several specific and global measures exist for assessing the quality of traditional written compositions. In the workplace, the problem is more complex. The developer must first determine how much of the material is actually read, how the material is used, and what process is involved in using a manual, filling out a form, following a diagram, or completing the multitude of literacy-related job tasks. Editing a brief telex memo or filling in a few blanks on a form may involve more language processing than composing a two-page essay on one's personal experiences.

Literacy Task Analysis

Trainers in business, government, and the military have developed effective techniques for task analyzing jobs to determine key tasks and the competencies related to those tasks (Miner and Miner, 1977, pp. 162-168; Beatty and Schneier, 1981, pp. 79-83; and U.S. Dept. of Labor, Handbook for Analyzing Jobs, 1972). This approach is recommended for developing basic skills components for vocational and technical training programs and generally involves the following activities performed on-site:

- observation of job occupants
- interview of job occupants
- examination of job descriptions
- observation (with questioning) of work activities
- collection and analysis of job-related printed materials

These methods, effective for general job analysis, can be applied to the literacy aspects of jobs or basic skills components. Results from these methods can be integrated into vocational and technical education and training. For an example, see the results of a partial literacy task analysis of one of the key functions of an entry-level word-processing specialist in **Appendix B.**

In conducting task analyses of specific jobs, one objective of the instructional developer is to identify those aspects of a job (i.e., skills, competencies) that are critical to the successful completion of a task. Since basic skills instruction will be based on the analysis of the tasks a worker performs in a given job, it is important that the developer focus on the appropriate set of skills. Developers conducting task analyses will benefit from the work of Greenan. Greenan has identified approximately 115 skills generalizable to more than 70 jobs. Developers conducting task analyses can use Greenan's generalizable and important skills matrix as an initial guide for what skills to look for in a particular job. For example, Greenan has identified the following reading skills as highly important for students in industrial maintenance occupations:

- o read, understand, and find information or gather data from books, manuals, and directories
- o read and understand forms
- o read and understand short notes, memos, and letters
- o read and understand graphs, charts, and tables to obtain factual information.

A developer conducting a task analysis of an industrial maintenance job could be alerted to look for instances where these reading skills are used. Specialized skills unique to a particular employer could be examined later.

It should be noted that reading a chart or graph in one occupation may require a different set of skills than reading a chart or graph in another occupation (e.g., reading a nursing chart requires different skills than reading a mechanic's oil quantity chart). It is suggested here that Greenan's work is useful as an initial guide to developers as they task analyze jobs. Thorough literacy task analysis of a job is required to refine and custom-design training materials which will be effective for occupational basic skills training.

For students to make improvements in occupational basic skills they need to spend time using materials very similar to those encountered in the workplace. Teachers and instructional developers can design and integrate such materials into existing occupation-specific training.

Steps for Conducting Literacy Task Analysis

Below is an overview of the process for conducting literacy task analysis teachers can use to develop occupation-specific basic skills training materials. The model is a simple one because it is understood that teachers and educators are not necessarily trained instructional designers. The process does, however, allow teachers to create lessons that can improve students' basic skills performance. **Appendix C** is a list of the steps that are explained below.

The "Before" Phase

The "Before" phase of the literacy task analysis process refers to the preparation necessary before conducting the interview and observation.

Once the occupation has been selected, the developer must identify which basic skills tasks to focus on for the observation. Greenan's important skills matrix, (Greenan, 1983) and the NAEP study results (Kirsch and Jungeblut, 1986), which identify various literacy tasks, are useful in determining which job skills to analyze.

The NAEP study identifies three types of reading materials encountered by adults: prose (e.g., reference manuals), document (e.g., job applications, maps, indices, charts), and quantification (e.g., totaling an order form, figuring a tip). When determining which job tasks to analyze, developers should choose tasks using materials from these three areas so that each reading type is represented in the job tasks analyzed. This will ensure a balance in the basic skills observed and provide students with practice in a representative variety of work-related reading materials.

The "During" Phase

The "during" phase refers to the structured interview, worker observation, and the gathering of work-related literacy materials. The purpose of the interview is to determine the critical job tasks involving basic skills, and to learn from the worker how these tasks are performed. The interview should be structured to provide the interviewer with a sense of how the worker actually thinks through the job tasks being studied.

One way to get the needed information is to ask questions that allow the interviewee to "model" the process. For example, the interviewee can be asked to explain a task this way: "If you were going to train a new worker how to do this part of your job, what would you want him to know?" Questions like this allow the worker to talk about the process of doing the task and can provide the interviewer with otherwise hard-to-elicit information.

An interview focusing on how superior workers make literacy-related decisions is an effective way to determine what important skills are needed by new and less-competent employees. The sample literacy task analysis (see **Appendix D**) provides indicators of what literacy skills are required for effective job performance. Such indicators are sufficient for screening. If employee performance is to be improved, however, trainers need to know how superior workers use these skills.

Steps for Curriculum Development

A simple basic skills training component for vocational and technical education purposes is comprised of the following components:

o cloze exercise with key vocabulary to diagnose ability

o vocabulary exercises to reinforce key terms

o simple modeled version of simulated task to show how to integrate basic skills

o one to two practice version(s) of simulated task(s) with feedback

o extended practice of specific sub-competencies (e.g., graphs, etc).

A cloze test can help teachers determine a reader's ability to understand materials that have been gathered from the workplace. The cloze procedure measures the ability of the reader to understand a passage's sentences at a literal or factual level. To construct a job-related cloze test, a copy is made of material (at least 150 words in length) that is clearly used in job performance. After an introduction of 25 words or so, every fifth word should be blanked out. The student's ability to accurately replace blanked out words can be used as an indication of ability to comprehend the material at a basic level (50 percent replacement is considered excellent). The percentage of correct replacements can be converted to grade level equivalents using Bormuth's (1975) tables. The tests should be given to current workers on the job to determine performance expectation levels. If only a short training time is available, it is not advisable to set performance cutoffs more than two to three grade levels below the level of current employees. Longer training time can allow the acceptance of less-literate entry-level workers. Two examples of job-related cloze tests can be seen in **Appendices E** and **F**.

Based on cloze test results, students can be directed to 1) remedial reading in low-level occupational materials (see **Appendix G** for materials for low-literate adult learners) 2) practice in occupational vocabulary or 3) more advanced occupational material.

One component of the basic skills training will be a simple modeled version of a job task. That is, the teacher or the materials can model, or show, students how to complete a job literacy task (e.g., filling out an auto service ticket, or writing down important notes from instructions given by an employer). After seeing the task modeled (several times if necessary), the student can practice the task on his or her own.

Based on the performance of the task, the teacher can direct students to additional practice, or repeat the modeling process for students who fail to perform at the predetermined level. Students who meet performance criteria can be directed to practice various subtasks (e.g., reading graphs or charts, computing totals on service forms, etc.).

This describes the fundamental core basic skills training. Adaptations that allow students to work together can be implemented with success. As developers become more experienced in creating training materials, it is desirable to create graduated simulation materials based on the literacy task analysis. Students who perform at a higher level on the initial simulated task can be directed to tasks requiring higher-level processing skills. As students progress, they can be introduced to extended content training with job materials in the following areas as they apply to specific occupations:

- o vocabulary
- o use of manuals
- o use of graphs
- o specialized skills

Content Area Reading

Applying literacy task analysis techniques to create occupation-specific basic skills training is the most effective way to develop basic skills training for entry-level employees. Integrating literacy tasks and job-specific problem-solving strategies helps the adult learner retain basic skills training and transfer it from the classroom to the workplace.

Conclusion

We have more than one literacy "problem" in the United States. The problem receiving the most media attention is the small percentage of adults who can barely read or write. A much larger and different problem concerns the millions of adults who can read and write but not well enough to meet the increasing literacy demands for entering and succeeding in a technologically-advanced workplace. Confusion of these two different literacy problems, and the fact that these problems need to be addressed using different methods, has led to a number of embarrassing misunderstandings, including a national advertisement falsely claiming that by the year 2000 two out of three Americans will be illiterate.

The line between who has and who has not gained enough literacy to function and thrive in the United States is, to a great extent, drawn along racial and ethnic lines. This division implies a dangerous potential for future social conflict along racial and economic lines. The potential for conflict is exacerbated by the fact that the public schools will soon face even larger percentages of minority youth--sons and daughters and brothers and sisters of the students with whom the schools have already failed. The gap between those with access to knowledge and those without is rapidly becoming a racial gap.

On the positive side, there is a growing awareness that, to be effective, basic literacy training needs to be integrated with functional uses of literacy. Though the nation is not experiencing the mass literacy mobilization Kozol (1985) calls for, there is a clear increase in awareness, volunteer efforts and resources on the part of individuals and businesses. Though there has been no comparable increase in state and federal resources for literacy training, there are indications that increased public awareness may lead to increased congressional awareness.

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Appendix A

SUMMARY OF ON-THE-JOB READING

from the Occupational Literacy Education handbook

R. Timothy Rush University of Wyoming, *Alden J. Moe*, Louisiana State University,
and *Rebecca L. Storlie,* University of Minnesota

Occupation	Average Daily Reading Time (minutes)	Type Material	Readability Score	Use	Frequency	Prose Style
Account Clerk	120	Correspondence, ledgers, lists, tables	Grade 13 to College Grad	To do	Daily	Informal, formal
Auto Mechanic	60	Technical references, memos, work orders	Grade 10 to College Grad	To learn, to do	Daily	Informal, formal
Draftsman	45	Technical references, blueprints, code books, reference books, memos	Grade 10 to College Grad	To do	Daily	Informal, formal
Electrician	120	Technical references, blueprints, schematics	College Graduate	To do	Daily	Informal, formal, technical
Heating/Air Conditioning Mechanic	45	Manuals, blueprints, memos	Grade 10 to College Grade	To learn, to do	Daily	Informal, formal
Industrial Maintenance Mechanic	42	Service manuals, handbooks, operating manuals, memos, workorders	Grade 10 to College Grad	To learn, to do	Daily	Informal, technical
Licensed Practical Nurse	78	Charts, tables, card files, handbooks, reference books	Grade 10 to College Junior	To learn, to do	Daily, weekly	Informal, formal
Machine Tool Operator	36	Manuals, handbooks, checklists, memos	Grade 9 to College Grad	To do	Daily	Informal, technical
Secretary	168	Reference books, tables, lists, letters, handbooks, memos	Grade 16 to College Grad	To do	Daily	Informal, formal
Welder	24	Blueprints, tables, memos	N/A	To do	Daily	Informal

Appendix B

LITERACY TASK ANALYSIS

Entry-Level Word-Processing Specialist

Function: I. Setting up and entering a job.

Key Literacy Task Description

I-1

Reviews job ticket to note type of job, originator and turnaround time, and job specifications including special instructions for format, typeface, and editing. If hard copy source document, scans for any illegible information and, where necessary, contacts originator's secretary for clarification. When other than standard work, may discuss with originator most effective format for desired document according to its purpose and use.

I-2

Keys appropriate functions to set up margins, type, spacing, and special features, according to document specifications on job ticket or standard style and format guidelines.

I-3

Proofs stored information using CRT and edits for grammar, spelling, punctuation, verb/subject agreement. (For magnetic typewriters, proofs after printout.)

Related Literacy Competencies

1.1 Read and comprehend written instructions concerning job specs.

1.2 Determine appropriate document format and style using manual.

1.3 Effectively frame questions to elicit needed additional information over phone.

2.1 Apply and use company's style manual.

2.2 Use manual, logic, and inference to solve non-standard problems.

2.3 Perform computations, centering and spacing.

3.1 Perceive verbal detail and differences between original copy and text.

3.2 Read and comprehend final text. Check meaning of sentence and paragraphs.

3.3 Proficiently apply grammar, spelling, and punctuation.

3.4 Apply company style and format guidelines to text.

Appendix C

TASK ANALYSIS AND DEVELOPMENT MODEL FOR TEACHERS

BEFORE

1. Choose an occupation
2. Identify frequent and/or highly critical tasks involving basic skills

DURING

3. Interview an experienced worker about the reading, writing, and computation done on the job
4. Interview the worker's supervisor about job tasks
5. Observe the worker reading, writing and performing computational tasks on the job

AFTER

6. Gather samples of reading, writing, and computational materials
7. On basis of observation, interviews, and materials, further analyze the job tasks
8. Identify technical vocabulary
9. Create cloze tests with material from the job
10. Create exercises that simulate the job task

Appendix D

LITERACY TASK ANALYSIS
Set-up Chart Example

Room set-up charts used by maintenance personnel at a hotel convention center are examples of workplace reading. The information on the chart is used to prepare a room for a meeting. The process is fairly complex and mistakes cause a good deal of problems and extra work. Knowing how superior workers "read" the charts can be useful in training new and less effective workers.

LITERACY PROCESSES	METACOGNITIVE SKILLS INVOLVED
Initially I consider what it is I need to accomplish and when it needs to be completed. Do I have enough information on the form and set-up chart to be able to correctly set-up the room?	Clarify purposes Self question
I need to set up the room as indicated on the set-up chart; locate the necessary equipment; and complete it in time for the meeting.	Organize and categorize sub tasks
I know where I can locate the A.V. material and all of the furniture except for a table for the projectors. I need to find something else to use.	Regular self monitoring and focus on new key aspects
I not only need to know how to read the chart, I need to know the terms for the A.V. materials and where to find them.	Requires both special chart skills and knowledge of workplace
What needs to be done? I need to get the room set up as indicated on the chart and need to find an alternative for the A.V. small table. Systematically check placement using chart. Check equipment.	Organizing ideas Monitoring progress Focus on each key detail

Appendix D (cond't)

HOTEL CONFERENCE CENTER

Convention Department

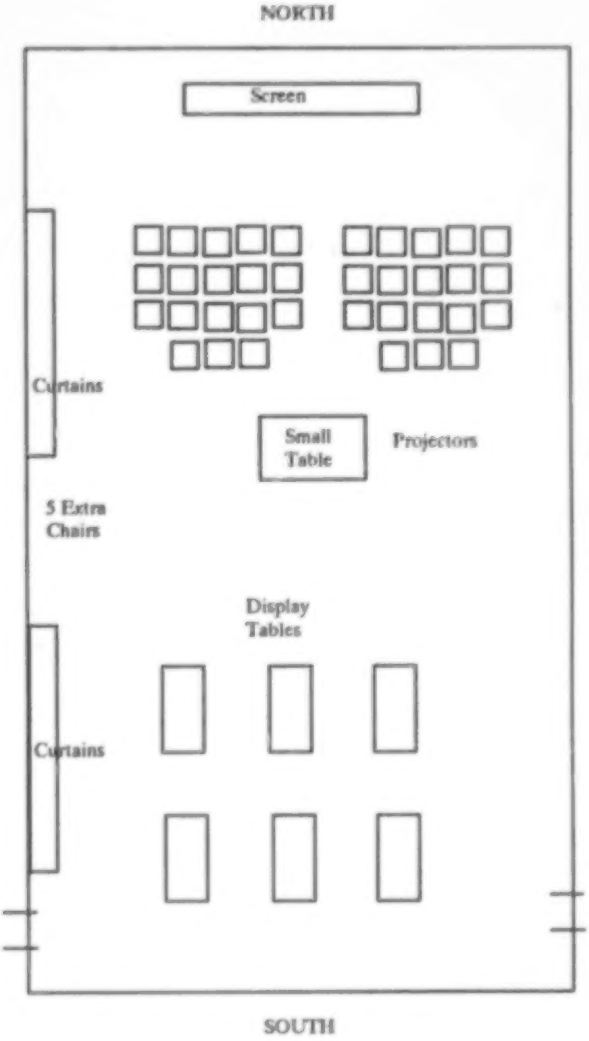
Nicholet Room

Program ______________________________

Contact Person ______________________________

Day ______________ Date ______________ Time ______________

Room Capacity ____________


NORTH
Screen
Curtains
Small Table
Projectors
5 Extra Chairs
Display Tables
Curtains
SOUTH

A.V. Equipment:

overhead projector
film projector
cassette player
screen
small table for projector

Other:

5 extra chairs
check that curtains close completely
6 display tables

Appendix E

OPERATION AND CONTROL

Controlling Spooling

One of the functions which the VM/370 system operator often controls is spooling. What makes an operator the "Spooling Operator"? People who have Class D command privileges are spooling operators.

What is their job? Figure 3.9 on the following page illustrates some of the things which a spooling operator is called upon to do.

Look at the person placing the deck of cards into the card reader. The spooling operator should verify that a user ID card precedes any deck of cards sent to the machine room by a user. The ID card will cause the deck to be placed into the user's virtual card reader (that is, space on a spool disk).

The spooling operator also is _________ to maintain a supply_________ blank cards in the _________ for the card punch. _________ the card punch run _________ of cards, an intervention _________ message will appear on _________ system console.

In addition_________ keeping a supply of____ ____ cards in the card _________, the spooling operator must _________ provide the proper paper _________ the printer(s). This may _________ between normal stock paper ________ _ special forms required for _________ purposes. When the latter _________ the case, the spooling _________ is also responsible for _________the loading of the_________ buffer, forms control buffer,_________ controlling the printing of _________ which require special forms.

_________ are a series of_________ DCP commands for _________ and determining the status _________ spool files. Upon determining the status the spooling operator can then stop, start, restart, or rearrange the sequence in which spool files will be printed or punched.

Finally, the spooling operator is responsible for separating punched and printed output according to user identification. Later we will take a look at some of the CP commands which pertain to the spooling operator.

DIRECTIONS:

Appendix F

The following passage is to help us find out how easily you can handle the type of reading you may have to do during your training and on the job. Take a moment to look at the section. Notice that many words have been replaced by blanks. Read the selection carefully. Fill in every blank with a word that makes the most sense. Don't worry if you aren't sure about all of your choices, you don't have to get every one correct.

Xerox 860 Operator Manual

THE REFERENCE GUIDE

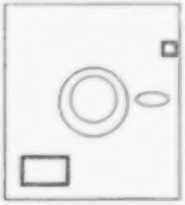
To go along with the manual there's a Reference Guide. This is an additional source of information about the 860 Information Processing System.

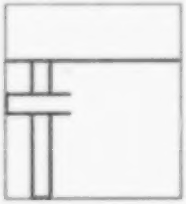
In your Reference Guide _________ find instructions on how _________ change print wheels, install _________ ribbons, even how to _________ diagnostics to check out _________ system.

There's also a section _________ the messages you'll see _________ the screen. Should the _________ display a message that's _________ to you you can _________ look it up in _________ Reference Guide.

TRAINING DISCS

The 860 _________ discs to record all _________ information. The illustration below _________ a disc and a _________ jacket. When you're not _________ a disc, keep it _________ its jacket.





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CHAPTER THREE

Basic Mathematical Skills for Vocational Education

by

Scott W. Gillie
Peter Kloosterman, Ph.D.

THE WORK-EDUCATION BRIDGE

SPRING 1988

Basic Mathematical Skills for Vocational Education

by
Scott W. Gillie
Peter Kloosterman, Ph.D.

The issue of how best to teach basic mathematics skills to vocational education students has been a subject of discussion for many years. The fact that related issues keep reappearing is evidence that solutions to the problem of how to teach basic mathematics skills are difficult to obtain. It is our perception that much of the lack of success in teaching basic skills is the result of an inadequate understanding of what skills are basic and how these skills should be taught. In this paper, definitions of basic mathematical skills are examined and then applied to vocational education. The conclusion discusses the Work-Education Bridge (WEB) as a strategy for linking mathematics instruction with the mathematical problem-solving content of jobs.

Defining Basic Skills in Mathematics

Historically, the primary goal of school mathematics instruction has been to teach students to add, subtract, multiply, and divide numbers accurately and efficiently. This goal made sense since many tasks, both on and off the job, required accurate manual calculations. Technology, however, has made pencil and paper figuring obsolete. Calculators and computers are so much faster and more accurate than humans that the need to teach students to quickly perform tedious calculations no longer exists. More than a decade ago the National Advisory Committee on Mathematical Education (NACOME) noted:

> Impending universal availability of calculating equipment suggests emphasis on approximation, orders of magnitude, and interpretation of numerical data--not drill for speedy, accurate application of operational algorithm. (National Advisory Committee, 1975; in "Position Statements on Basic Skills," 1978, p. 24)

In the years since the NACOME report, calculators and computers have, in fact, become widely available. The report's prediction of how technology would influence mathematics teaching closely resembles current content trends. For example, in 1985 an advisory committee of the National Council of Teachers of Mathematics (NCTM) reported:

> The major influence of technology on mathematics education is its potential to shift the focus of instruction from an emphasis on manipulative skills to an emphasis on developing concepts, relationships, structures, and problem-solving skills. ("Impact of Computing Technology on School Mathematics: Report on an NCTM Conference," 1985, p. 14)

The NCTM added that "significant portions of the elementary curricula devoted to algorithms for multiple-digit calculations can be eliminated." ("Impact of Computing Technology on School Mathematics: Report on an NCTM Conference," 1985, p. 15)

In short, the presence of calculators and computers, while not eliminating the need for learners to compute, has refocused the educational goal from calculating quickly and accurately to understanding why computational procedures work and knowing when to apply them.

Unfortunately, many individuals still believe that fast and accurate manual computation is necessary today. For example, Kloosterman and Harty (1986) found a number of service industry employers of high school graduates who complained about the computational skills of individuals they had recently hired. While the employers felt that drilling students on computational skills would solve many of the computational problems, further questioning revealed that the workers' inability to decide which computational algorithm to apply or how to begin solving an "on-the-job" problem caused more difficulties than errors in computation. A calculator can correct the problem of computational errors, but it cannot tell an individual which computation is needed to solve an "on-the-job" problem.

Math Supervisors' Definition of Basic Skills

Reacting to the "back to the basics" movement of the 1970s, the National Council of Supervisors of Mathematics (NCSM) drafted a document outlining what it perceived to be basic mathematical skills. Their document listed 10 basic skill areas:

1. Problem solving
2. Applying mathematics to everyday situations
3. Alertness to the reasonableness of results
4. Estimation and approximation
5. Appropriate computational skills
6. Geometry
7. Measurement
8. Reading, interpreting and constructing tables, charts, and graphs
9. Using mathematics to predict
10. Computer literacy

("Position Statements on Basic Skills," 1978, pp. 148-150)

Note that "problem solving" is at the top of the NCSM list and that computational ability is only one of 10 skills areas identified.

Math Teachers' Definition of Basic Skills

In 1980 the National Council of Teachers of Mathematics (NCTM) published what has probably been the most cited document on mathematics training in recent history. The document, titled An Agenda for Action: Recommendations for School Mathematics of the 1980s, began with the recommendations that:

1. problem solving should be the focus of school mathematics in the 1980s, and

2. basic skills in mathematics must be defined to encompass more than computational facility. (An Agenda for Action: Recommendations for School Mathematics of the 1980s, 1980, p. 1)

Again, computational skills were regarded as necessary but not as important as problem-solving skills.

The National Science Board Commission on Precollege Education in Mathematics, Science, and Technology recommended the following curriculum for all students:

Algebra

- o Ability to recognize basic algebraic forms and how to transform them into other forms
- o Understanding of the logic behind algebraic manipulations
- o Skill in solving linear equations and inequalities
- o Skill in solving quadratic equations
- o Ability to graph linear and simple quadratic functions and use these in interpreting and solving problems
- o Familiarity with permutations, combinations, and simple counting problems
- o Knowledge of relations and functions
- o Development of problem-solving abilities

Geometry

- o Ability to think logically
- o Ability to work through short sequences of rigorously developed materials while de-emphasizing proof
- o Knowledge of two- and three-dimensional figures and their properties
- o Ability to think in two- and three-dimensions in terms of congruence and similarity
- o Ability to use the Pythagorean theorem and special right triangle relationships
- o Understanding of algebraic methods in geometry and analytic geometry; and vector algebra, especially in three dimensions
- o Familiarity with computer graphics packages to get a visual sense of geometric concepts and transformation

Other Mathematics

- o Knowledge of discrete mathematics (basic combinations, graph theory, discrete probability)
- o Understanding of elementary statistics (data analysis, interpretation of tables, graphs, surveys, sampling)
- o Knowledge of computer science (programming, introduction to algorithms and iteration)
- o Familiarity with the philosophical basis of calculus and understanding of the elementary concepts of the subject (e.g., rates of change, intuitive idea of limits). (Educating Americans for the 21st Century, 1983)

The above list presumes that all students will take at least three years of high school math.

Problem Solving as a Basic Skill

Problem solving was given primary importance in mathematics teaching by both the NCSM and the NCTM. To better understand the relationship between vocational education and basic skills in mathematics, it is useful to know what "problem solving" means to mathematics educators.

NCSM defined problem solving as "the process of applying previously acquired knowledge to new and unfamiliar situations." ("Position Statements on Basic Skills", 1978, p. 148) NCTM described it this way: "Problem solving encompasses a multitude of routine and commonplace as well as non-routine functions..." and "involves applying mathematics to the real world..." The NCTM further stated that "true problem-solving power requires a wide repertoire of knowledge, not only of particular skills and concepts but also of the relationships among them and the fundamental principles that unify them." (An Agenda for Action: Recommendations for School Mathematics of the 1980's, 1980, p. 2) Problem solving, as defined by NCSM and NCTM, encompasses much more than typical textbook word problems. Problem solving means solving work-related word problems, but it also means being able to transfer knowledge about one problem to a new problem, and to develop several possible solutions to a problem when information necessary for an exact answer is not known. In addition, problem solving means being able to communicate ideas for problem solution to other individuals so that a group can work together to solve a quantitative question. In short, problem solving, as we are defining it, can be thought of as synonymous with the "critical thinking" or "logical thinking" necessary to answer a question, regardless of whether that answer requires one step or 50.

Computation and Problem Solving: What Do Students Know?

The National Assessment of Educational Progress (NAEP) assesses student knowledge nationwide in a variety of subject areas. Testing in mathematics was done in 1973, 1978, and 1982. Five mathematical content areas (numbers and numeration; variables and relationships; geometry; measurement; and other topics) were assessed for 9-, 13- and 17-year-old students. Within each content area, questions ranged from simple recall to complex word problems. In this way, it was possible to determine how problem-solving performance compared with performance on definitions and simple computation exercises.

Data from NAEP indicate that 85 percent to 90 percent of 13- and 17-year-old students could accurately perform whole number addition, subtraction, and multiplication (Carpenter, et al., 1984). Long division problems were answered correctly only 50 to 70 percent of the time (Carpenter, et al., 1981) indicating that despite months of instruction on long division in grades 4, 5, and 6, a substantial number of students were not remembering the division algorithm. In the case of division, there was little improvement between ages 13 and 17, indicating that even applying the long division algorithm as needed for high school math courses was not sufficient to get many students to remember how to do long division.

National Assessment data on non-computational aspects of mathematics indicated that students in the United States were not very good at mathematical operations beyond whole number computation (Carpenter, et al., 1981, 1984). This finding does not imply that applying quantitative reasoning is beyond the capability of students. Rather, it implies that students have not been taught how to apply their quantitative skills. For example, the following national assessment problem was given to 13-year-old students: "An army bus holds 36 soldiers. If 1,128 soldiers are being bussed to their training site, how many buses are needed?" About 70 percent of the students performed the correct calculation (1128/36=31.333), but 29 percent gave 31.333 buses as the answer and another 18 percent gave 31 buses as the answer. (Carpenter, et al., 1984). These answers make little sense in terms of the question asked. Results such as this show that students have learned that, in mathematics, success comes from taking the numbers in a problem and doing a computation. They have not been encouraged to look at the logic or sensibility of their answer in terms of the question asked. This skill, however, is a critical "real life" skill that cannot be assigned to a computer.

The authors of Educating Americans for the 21st Century concur:

> Analysis of current student performance in mathematics--particularly the use of mathematical skills in unfamiliar areas--indicates that they are learning to be technicians but not problem solvers. (Educating Americans for the 21st Century, 1983, p. 42.)

Basic Mathematical Skills: Vocational Educators' Definitions

As was the case for mathematics educators, vocational educators historically defined basic mathematical skills in terms of computational skills. There is evidence that vocational educators are beginning to see problem solving as a critical basic skill. Greenan (1983) for example, talks about skills that are "generalizable" from one job or profession to another.

A generalizable skill is defined as "a cognitive, affective, or psychomotor skill (or skill area) which is a) basic to, b) necessary for success in, and c) transferable (or common) within and/or across secondary vocational training program areas and programs." (Greenan, 1983, p. 7)

Greenan (1984) lists 28 mathematical skills that are generalizable across a variety of occupations. The skills are fairly specific and include such straightforward skills as ability to "read and write common fractions" but also include more general problem-solving skills, such as the ability to "determine if a solution to a mathematical problem is reasonable." While Greenan is not using the problem-solving terminology of mathematics educators, he is clearly interested in developing basic problem-solving skills that are transferable across situations; and, thus, there is considerable overlap between his suggestions and those of NCSM and NCTM.

Additional examples of promotion of problem-solving skills in vocational education can be seen to varying degrees in a variety of other settings. Fadale (1984) outlines a program for in-service training of two-year college vocational instructors. While her program includes computational skills, it also includes a number of suggestions for activities that promote mathematical problem solving.

In contrast, King-Fitch (1985) has a very broad definition of the basic mathematical skills vocational instructors should teach, but gives suggestions for remediation of basic skills that are very rule oriented. A basic tenant of a good problem-solving curriculum is that there is a limit to which "following the rules" can be used to solve real-life mathematical problems. A module called "Learning to do Math the Drafting Way" (1984) addresses problem solving similar to the King-Fitch (1985) handbook. Some of the topics included require general problem-solving strategies, but more of the suggestions for teaching these topics revolve around nontransferable sets of rules.

The Center for Occupational Research and Development (CORD) is developing a series of 25 competency-based modules of applied mathematics instruction. The series is scheduled for distribution in 1988. Assumptions guiding the development of the series are as follows:

o Workers without mathematical skills are seriously handicapped because a knowledge of mathematics is essential to basic technological literacy.

o The ability to solve problems creatively by using a systematic approach is an essential skill for contemporary workers.

o The greatest transfer of mathematical skills occurs when the relevance to students' vocational interests is evident.

o The Applied Mathematics materials must meet the needs of vocational students from all major areas of vocational education (e.g., business, health, agriculture, etc.).

- The needs of the labor market must be addressed. (Center for Occupational Research and Development, 1987, p. 10)

Unit 7 of Applied Mathematics is titled "Learning Problem-Solving Techniques." The specific unit objectives are listed below:

- Read a problem and determine what is given, what is known, and what is to be found,

- Identify possible methods for solving the problem, including mathematical and graphical techniques,

- Select and carry out a method of solving the problem,

- Make a rough estimate of the expected answer, and

- Examine the results to verify the solution and determine its reasonableness. (Center for Occupational Research and Development, 1987, p. 23)

The CORD materials will provide both generic and occupationally-specific problems for students to solve. In addition, there will be videos that introduce the topics of each unit. The videos will serve to motivate students and underscore the applications and relevance to their vocational interests. These materials seem to reflect many of the concerns of mathematics educators regarding the importance of problem solving and application.

Computation and Problem Solving: What Can Students Be Taught?

An obvious concern when considering basic mathematical skills is that it should be possible to teach students the skills that we want them to know. In particular, if problem-solving skills cannot be taught adequately to vocational students, then it makes little sense to attempt to integrate a mathematical problem-solving curriculum with vocational courses. What do we know about teaching both specific and transferable mathematical skills?

As an introduction to a discussion of whether mathematical problem solving should be taught, it is important to note the success that schools are now having in teaching very specific mathematical skills. Much of the mathematical instruction taking place in schools today involves drill and practice on rules for obtaining the answer to a particular type of problem. However, there is evidence that the drill and practice method is not completely satisfactory. For example, the NAEP data reported earlier indicate that a sizable minority of students are not learning long division (Carpenter, et al., 1981, 1984). Employers of high school graduates indicate that new employees often have trouble with simple computations. (Kloosterman and Harty, 1987) In reviews of research on skill learning in mathematics, Driscoll (1980) and Suydam and Dessart (1980) state that drill and practice on computational rules is useful once students understand why a computational procedure works: If students do not understand a procedure, drill and practice will be of little value for long-term retention of the skill.

Research shows that students learn basic computational skills by relating new skills to previously learned knowledge. Students have mastered addition, subtraction, and multiplication because the algorithms for these computations can be easily explained in terms of place value concepts. In short, drill and practice is effective only as a means of increasing speed and accuracy on computations; it will aid students' long-term retention of the skills taught only if the students understand why the algorithm works. This is true for virtually all students, and thus any attempt to increase the basic mathematical skills should not involve drill on "rules" for getting the correct answer unless (a) the student understands why the rules work, or (b) the rules will be used so frequently that the student will not forget.

While much is known about teaching specific mathematical skills, less is known about the potential for teaching transferable problem-solving skills. However, with the advent of technological aids for computation, teaching students computational and problem-solving skills that they will remember without continual practice is the only reasonable goal for mathematics instruction. As one commentator puts it, "The best prepared worker for the future will be one who has both strong "learn-how-to-learn" skills and a sense of the specific skills and attitudes required in an occupation." ("Educating Youth for Work: The Role of the Private Sector," 1986, p. 2) How can students be taught to solve "real" problems and "learn-how-to-learn" skills?

There is a variety of instructional resources available on mathematical problem solving. For example, Krulick and Rudnick (1980) and Charles and Lester (1982) provide strategies for teaching students to solve "non-routine" word problems. Another resource is the 1980 yearbook of the NCTM, which focused entirely on mathematical problem solving. In addition, many publishers of pre-college mathematics texts now offer excellent problem-solving supplements (cf. Charles and Lester, 1982; Nibbelink and Shepardson, 1985). While print materials are only as good as the teachers who use them, preliminary research evidence indicates that well-instructed students can be taught to use transferable problem-solving strategies. (Lester, 1980; Kantowski, 1981; Charles and Lester, 1982; Silver, 1985)

Many programs for teaching problem solving include some variation of the general problem-solving heuristics Polya proposed in 1957. In brief, Polya suggests a four-step process:

1. understand the problem,
2. devise a plan,
3. carry out the plan, and
4. look back.

If students were taught to "look back," solutions such as those for the army bus problem mentioned earlier would be much less common. Only a small percentage of mathematics teachers, however, have been taught how to teach problem solving, and thus the available materials are not yet having a substantial impact on mathematics instruction. (Kloosterman and Harty, 1987)

In vocational education, materials to teach generalizable solutions to vocationally-related mathematical problems are rare. Greenan (1984) published a list of resources for teaching basic mathematical skills to vocational education students. His list includes a handful of innovative resources, but most are traditional texts that rely heavily on drill and practice of specific, nontransferable computational skills. Joe Karmos and Ann Karmos (1986) have described a five-step problem-solving model for both school and the workplace. The model adds a brainstorming step to the Polya (1957) schema, and involves group problem solving with the attendant dynamics of cooperation and teamwork. The Karmoses' problem-solving materials also include digests of strategies from Edward deBono (1982), Whimbey and Lochhead (1979).

Two articles included in the June 1983 Kappan, deal with thinking skills and problem-solving resources; the Karmoses also list an additional 10 resources. Some of the resources relate to mathematical problem solving, and, while none are occupationally related, many could be adapted to the vocational classroom. But even having good materials is no guarantee that they will be used, as evidenced by the infrequent usage of mathematical problem-solving materials that have been available for several years. If materials to teach mathematical problem solving are to be a part of vocational curricula, teachers must be taught how and why to use them.

Mathematics Instruction in Vocational Education: The Challenge

There is a body of evidence suggesting that the students who enroll in vocational education are of lesser proficiency than those in college preparatory courses of study. (Lotto, 1983) The Academic Growth Study (Hilton, 1971) provides a dramatic depiction of the contrast between students' achievements in college preparatory and vocational classes in mathematics:

> At grade 11 approximately four years of achievement separate the academic students from the vocational students. By eleventh grade, the vocational, home economics, and business students achieve an average level of sophistication in mathematics which the academic students had achieved by seventh grade. (Hilton, 1971, p. 51, as quoted in Lotto, 1983, p. 4)
>
> Hilton asserts that the differences between academic and vocational students appear as early as fifth grade with test score differences of approximately the same magnitude as that of the eleventh grade students mentioned above. (Hilton, 1971, p. 172, as quoted in Lotto, 1983, p. 4)

In addition, Creech (1974) found that non-academic students achieve at a level roughly one standard deviation below that of academic students. And Fetters (1975) showed that vocational students performed more poorly in mathematics than both academic and general students in the national Longitudinal Study of the High School Class of 1972.

Standardized measures probably exaggerate the differences between academic and vocational students. However, there is little evidence to suggest that secondary vocational programs are attracting more students from the academic cohort. Furthermore, test scores for all cohorts declined throughout the 1970s and early 1980s. For vocational teachers, the situation must appear that the requirements of work are increasing while the proficiencies of vocational students are, at best, staying the same. Vocational content must remain at a low level of difficulty, if vocational students do not possess the requisite basic mathematics skills. Certainly, the development of technical job-specific competencies is hindered by the low level of foundation skills of many vocational students.

For some educators, mathematics proficiency is a "pre-vocational" matter. The vocational students' lack of proficiency in mathematics is a cause of concern, but responsibility for addressing this concern is not a vocational matter. According to those who hold this point of view, the introduction of mathematics education into the vocational classroom will "institutionalize" the poor preparation of vocational students by the math department. Further, there are suspicions that, even if it would be appropriate to teach mathematics in the vocational classroom, vocational teachers are neither inclined nor qualified to teach mathematics.

As the following section will point out, there is no meaningful preparation for work, from an employer's perspective, that does not prepare a worker to learn on the job and adapt to changes. From the employer's vantage point, workers who cannot learn and adapt are not prepared for jobs. With this in mind, it should be the shared responsibility of all educators to ensure that students achieve proficiency in basic academic skills.

Employer Perspectives on Job-Related Mathematics

> [W]e should use vocational instruction as an alternative means to achieve academic learning. . . .In order to fully understand what they are doing, carpenters need to know some fairly sophisticated mathematics. . . .(Hamilton, 1986, p. 242)

> Medium to high levels of mathematics skills are required across job categories, according to responding business executives, with consistently high levels required in the manufacturing, utilities, and finance industries. (Henry and Raymond, 1982, p. 13)

> Employers report that mathematical skills are deficient across a wide range of job categories. (Henry and Raymond, 1982, p. 20) Specifically, employers report that miscalculations due to poor decimal and fraction skills result in "incorrect inventories, incorrect reports of production levels, and improper measurement of parts or machine specifications. . ." (Henry and Raymond, 1982, p. 20)

Concern about mathematics is one dimension of employers' perceptions of basic-skills deficiencies. Employers find large numbers of employees deficient in a wide variety of areas that include speaking and listening skills, science skills, and reading, writing, and reasoning skills. Collectively, these deficiencies contribute to limited upward mobility for workers and limited adaptability to changes in the workplace.

The learn-how-to-learn skills previously mentioned in this paper are apparently more important to employers than specific skills. Indeed, the Center for Public Resources' study of basic skills in the U.S. work force found the following:

> School systems appear to have underestimated the importance of basic (academic vs. vocational) skills for successful employment of students entering the work force. (Henry and Raymond, 1982, p. ii)

Students who are deficient in one area of basic skills are usually found to be deficient in other areas as well. On-the-job problem solving often involves combinations of reading, writing, speaking, listening, reasoning, and calculating. It is only in school that these subjects are experienced as isolated, discrete entities. Employers recommended to Kloosterman and Harty (1986) that math problem solving be integrated with other skills such as writing:

> "In the past, one person did the math calculations, and another did the writing," he [John Dossey, professor of mathematics at Illinois State University and President of the National Council of Teachers of Mathematics] said. "But when [job] recruiters come to campus here, they are looking for students who can speak and write clearly, and then someone with appropriate math skills." (Rothman, 1987, p. 6)

In Educating Americans for the 21st Century, (1983), the authors note that the majority of new hires by businesses through the year 1995 will not be college graduates. A survey by the Science Board shows that American businesses are increasingly showing interest in secondary and elementary education:

> Business is particularly focusing on the quality of elementary and secondary education as it relates to the learning skills, problem-solving abilities, and discipline of new employees entering the labor force. (Educating Americans for the 21st Century, 1983, p. 83)

The Work-Education Bridge

An Indiana University interdisciplinary team of researchers has devised a schema for addressing the problem-solving needs of learners in the classroom and the workplace. Termed the Work-Education Bridge (WEB), the research team has developed a set of procedures for task analyzing occupations for basic academic skill content and for converting the task-analysis data to instructional materials.

The WEB process ascertains the "critical academic skills" for job performance and provides for the development of learning materials that incorporate the problem-solving procedures, tools, standards, written materials, and working conditions into the curriculum. This process is expected to yield a high degree of transferability to the workplace as well as improved learning and retention on the part of vocational students. The close approximation of the workplace and simulation of workplace activities in the classroom will also contribute to realistic expectations on the part of job entrants and will provide a rationale for the acquisition of basic academic skills by vocational education students.

Conclusion: Vocational Education + Basic Academic Skills = Good Preparation for Work and Further Learning.

Vocational education offers an experiential context in which to address basic academic skills. In order to proceed in this direction, vocational educators must assume responsibility for academic outcomes, and vocational students must reorient their perception of vocational education as an alternative to academic education.

> Opportunities should be provided for the application of arithmetic and mathematics in a variety of areas--in the natural and social sciences, in consumer-related experiences and in other real-life situations where analysis through mathematics is possible. (Educating Americans for the 21st Century, 1983, p. 43)

Current trends seem to favor academic education over vocational education and call for expanded studies of academic subjects. (Ferqueron, 1984) For those vocational students who learn best by doing, and who prosper in situations that emphasize the concrete, visual, and manipulative aspects of learning, current trends are ominous. One wonders how additional time spent on academics is going to help these students. Perhaps vocational education that affords genuine opportunity to continue academic learning should be offered earlier, rather than later, in students' programs. Certainly, a disservice is done to students by the rigid insistence upon separating the vocational from the academic. Outside of education, where else in the world is this separation maintained?

In a vocational education environment in which there is an integration of basic mathematics, and in which problem solving is a primary focus, there will exist opportunities for students to attain considerably more than job-specific skills. There will exist opportunities for them to attain the technological preparation. Such opportunities may do much to attract more students from the academic cohort and, in so doing, help to ensure that vocational education programs will better meet the requirements of a changing world of work.

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CHAPTER FOUR

Basic Science Skills in Vocational Education

by

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THE WORK-EDUCATION BRIDGE

SPRING 1988

Basic Science Skills in Vocational Education

by
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There is a need for technology as an element of general (secondary) education. (Raat and de Vries, 1985, p. 4)

> The education required to prepare individuals for postsecondary education and training for high-technology occupations is clearly composed of mathematics, language, science, and computer literacy, along with critical thinking and reasoning skills. Schools at all levels are faced with the challenge of providing these skills. Educators need to study ways to improve cooperation and increase articulation among programs so as to provide these skills. (Lemons, 1984, p. xii)

Our society is facing technological change at a rate that few of us even imagined a short time ago. We refer to these developments as the "information age," a period in which technology permeates everyday activity. Technology and science are strongly related, and educators, including vocational educators, are now facing the question of how to teach these subjects effectively. Related issues are how to ensure that there will be an adequate number of science teachers, how to interest all students in the sciences, and how to relate science and technology to a workplace that is constantly changing. This paper will define the basic science skills, relate them to vocational education and the workplace, explore how to integrate science skills in vocational education curricula, and discuss two Indiana thrusts in the area of basic science skills in vocational education.

Basic Science Skills

The basic science skills are rooted in the notion that knowledge develops inductively from sensory input or is inferred from experience. Two appealing reasons for gearing vocational education programs toward a basic science skills approach are its representation of the spirit of science and its linkages with the enhancement of intellectual skills necessary for successful functioning in everyday life.

Vocational teachers need to be familiar with and apply the basic science skills if they are to help vocational students understand and use these basic skills. In a manner similar to students, teachers need to experience these processes in order to become sensitive to and understand what students are experiencing. To this end, illustrative hands-on activities need to be provided for each science process. In this way, teachers can acquire confidence in their ability and be more "tuned in" to a given basic science process skill while it is being taught. Basic science skills can bridge the difference between training (knowing) and education (knowing and understanding).

Science process skills provide students with the necessary ingredients for making sense out of chaos, sorting things out, and putting things into perspective. These skills are referred to as science processes because scientists use them when they investigate problems. However, the process skills are not only used in science but are applicable to most, if not all, areas of vocational education. The process skills also have a tendency to generate curiosity, excitement, and overt activity among students.

One assumption in this paper is that if vocational education students acquire these basic science skills, they will have the tools to understand any vocational education content taught to them. These process skills are not unique to science; rather, they can serve as a template for the process of literacy task analysis. An assumption that should not be made is that all students are equally capable of acquiring the basic skills at a given age. Much rests on a student's experience and level of intellectual development.

A basic science skills approach is not without its limitations. Tradeoffs are necessary when a vocational education teacher employs such an approach. For example, if students are taught exclusively by this method, then they cannot be expected to acquire a great deal of vocational technical content, or to understand many vocational technical concepts in a given area. Also, if basic skills are taught in the absence of conceptual knowledge, students may convey an inadequate and/or inaccurate view of the basic skill. A reasonable sequence of skill development activities must be maintained if students are to benefit from a skill development hierarchy.

Relationship to Thinking Skills

Science process skills and many of the mental operations and schema associated with learning and intellectual development are interrelated. Each process is a specific intellectual skill necessary for understanding phenomena. Students develop higher cognitive-level thinking skills through inquiry teaching and learning environments, because inquiry learning requires students to utilize one or more of these basic skills. The basic skills are psychomotor mechanisms that allow students to collect and reflect on data or information for themselves. As students acquire the science process skills, they also develop intellectual skills that can be applied to out-of-school activities.

Skills Development Hierarchy

Students' use of upper-level science process skills depends on their ability to use the simpler underlying skills. Science process skills are hierarchically arranged in a pattern sequenced from the simple to the complex:

- observing
- measuring
- classifying
- using space/time relationships
- inferring
- predicting
- communicating
- defining operationally
- controlling/manipulating variables
- formulating hypotheses
- interpreting data
- experimenting

The skills overlap in their development and application and it is often difficult to separate the skills from one another. For example, the skill of observing is the basis of the other skills. Thus, it is nearly impossible to teach a skill in isolation.

Defining Basic Science Skills

Observing. One of the most natural actions of students is that of observing. Observing is the most basic and widely used skill; all five senses are utilized in identifying and describing the attributes and characteristics of objects, events, or situations. Observation requires attention to detail as well as to the big picture (i.e., seeing both the trees and the entire forest).

As students' observational skills become more sophisticated, they begin to see how objects and systems interact and they begin to seek explanations for the interactions. Observations can be qualitative or quantitative, static or dynamic. A static or stationary observation deals with things that are unchanging. Dynamic or moving observations focus on things or objects that are undergoing change.

The skill of observing is the basis for all scientific activity and most aspects of learning. Information obtained by observation can foster greater curiosity, more frequent student questioning, reflective thinking, and additional hypothesizing. Creating an environment for students to become discriminating observers should be one of the major goals of vocational education.

Measuring. In its most rudimentary sense, measuring means matching things (e.g., objects, events) with a standard measuring tool (e.g., thermometer, balance, timing light), or comparing one object to another to determine which is longer, heavier, etc. In some circles, measurements are referred to as quantitative observations. Students' observational skills can be enhanced when they measure things, because observations can be more meaningful if they are quantified. Understanding the basics of measurement will allow students to acquire more readily the quantitative thinking they will utilize when carrying out their vocational interests.

Students can learn to quantify what they observe by using appropriate estimating devices. They also need to understand that there are appropriate units of measurement for length, area, volume, temperature, weight, time, energy, etc. Measuring is usually employed in conjunction with other arithmetic operations and skills; this is often the case when measuring things outside of school and in most jobs.

Measuring skills are also necessary for grouping and classifying, and for communicating reliability and validity. Communications, and the more formal process of dissemination, can also become more precise by way of appropriate measurement. The more precisely students communicate their findings and display their data, the easier it will be for other students to engage in the same activity and replicate findings.

The skill of measuring takes into account several mathematical processes, including basic operations such as addition, subtraction, multiplication, and division. Undergirding these operations are the subskills of counting and tallying. In addition, measurement requires other mathematical skills such as:

o solving problems requiring single calculations for open-ended questions

o inferring functions and relationships where the association of one variable with another is uncovered

o using tables and graphs to communicate data to others, making predictions, observing relationships among variables, speculating about changes in data, and making conclusions

Classifying. Classifying is the arranging of things, situations or events into a scheme according to some property or attribute (e.g., grouping things according to similarities or differences). The most common properties used for classifying are shape, color, size, or the presence or absence of an attribute. The process of classification is a systematic arranging or ordering of objects and materials in a series of groups.

The essence of classification is to give order to collections of things. Classification schemes are designed to give meaning to information, organize data, and facilitate communication. Classifying schemes can be used to identify objects or events or to show similarities, differences, or interrelationships; to group objects for some defined purpose; or to fulfill some utilitarian goal.

In order to classify, students need to make a distinction between attributes and values. An attribute is a distinct but somewhat generic property, such as color, texture, shape, size, or composition. Values are definitive variations or operationalizations of attributes. One way to make a distinction between them is to think of attributes and values as representing different levels of abstraction. For example, the attribute "texture" is more abstract than the value "rough." The values for the attribute texture could be smooth, rough, pitted, etc.

Using Space/Time Relationships. This process focuses on the position of objects or events in regard to other objects or events or to different points in time. The process has five basic subsets: 1) shapes, 2) symmetry, 3) direction and spatial arrangement, 4) rate of change, and 5) motion and speed. Students understand spatial relationships when they have to describe their own position in terms of a point of reference, such as positions of other people or things. Another way to use space/time relationships is to identify the effects of motion as they relate to factors of effort, direction, appearance, time, and distance. Space relationships generally involve the processes of observing and measuring (estimating).

The use of space/time relationships is instrumental in students' perceptual development. Many of the decisions students make in daily life (e.g., mowing a lawn, cleaning a bedroom, shoveling snow, washing a car, etc.) and vocational-technical teachers make in their classes focus on space/time relationships. Students, in the course of a day, will face situations where better decisions will be founded on an ability to discern spatial and time relationships.

Inferring. Inferring involves interpreting or explaining what has been observed. Inferences are suggestions about a set of conditions that have been observed or explanations of relationships among the parts of a system. From another perspective, an inference may be defined as a statement delineating a cause-and effect relationship. Some say educated guesses are inferences, but they are really more than guesses.

Much of what we do or how we behave is based on the inferences we make about situations, events, things, or objects. Vocational-technical teachers can help students make inferences by allowing them to: 1) practice observing only indirect or incomplete data or information, 2) distinguish between observations and inferences, 3) make tentative conclusions from observations and inferences, and 4) make predictions from data that an event will happen or has happened. Multiple inferences may be made in order to explain an observation.

Students need to distinguish between observing and making inferences about something. Often, inferences are interpreted to be facts or a series of valid observations, or they are just mistaken for observations. Inferences go beyond direct observations using the senses and involve mental manipulations for interpretation purposes. Often, an important by-product from discerning between inferences and observations is a tendency not to jump to conclusions.

Predicting. Predicting means forecasting what might happen based on direct observations and past experiences. Predicting is often thought of as a highly developed form of inferring. A prediction is a forecast of what a future observation will be if an event or test situation is extended or repeated. Predictions are based on observations, measurements, and inferences about relationships between observed factors.

Predicting appears to be closely related to and highly dependent on the skills of observing, measuring, classifying, and inferring. Predictions can be formulated only after making a series of related observations and subsequent measurements. The more measured data available from previous experiences, the more accurate the predictions that can be made.

Predictions, and the ability to make predictions, often are founded in a student's background and/or past experiences. Predicting may be difficult for students who have limited experiences or isolated lives. When selecting activities for lessons on predicting, vocational-technical teachers must choose only those activities to which students can relate.

Communicating. In a general sense, communicating is the exchange of information. This basic science process skill involves the placing of data (e.g., facts, figures, findings, etc.) collected from observations into a usable format so that another person can understand and use them.

Students need to communicate in clear, precise, and unambiguous ways. To accomplish this, a wide range of skills must be developed and practiced. The simplest manner in which students develop communication skills is by describing objects, things, or events in detail. Putting information into tabular, graphic, or pictorial format is another means of communication.

Defining Operationally. Operational definitions are used to identify and describe terms, things, or events unambiguously. They consist of observations that describe a thing or event by explaining what actions were performed and what was observed. When defining a concept or process operationally, it is described by actions or functions rather than by contextual terms alone.

When students choose a method to measure a variable, they must formulate an operational definition. To define a variable operationally usually involves a determination of how it will be measured.

Operational definitions differ from dictionary definitions because they synthesize what has been done and observed. The distinction between operational and nonoperational definitions should not be confused with the differences between good and poor or between useful and useless operational definitions. Operational definitions also may be changed or refined over time because they are situationally based. In addition, more than one operational definition may be used in a given situation. Students should be encouraged to suggest and use alternative definitions.

Controlling/Manipulating Variables. Variables are the dimensions or factors operating (or not operating) within the context of an experiment that can be maintained, changed, or manipulated in some way by the student. Stated more simply, a variable is any factor that may or may not change that can influence a situation or a system. Scientists control and manipulate variables to show causal relationships. They attempt to show that a manipulated (independent) variable causes a change measureable in a responding (dependent) variable by controlling all other variables or influences.

The skill of controlling/manipulating develops logically from an ability to consider all possible combinations of influences that might have some effect on the outcome of an experiment. All factors are held constant except the one factor that is being tested in the experiment. Controlling all variables except one allows students an opportunity to explain the results and draw conclusions. The goal is to develop student mastery in identifying, manipulating, and controlling variables as a prerequisite to designing and conducting their own experiments. When students manipulate and control variables, they learn to manage the conditions of an experiment. This skill requires students to function at a high level of intellectual development.

Formulating Hypotheses. The mental activity of generating an idea to test is often referred to as hypothesizing. A hypothesis is a general statement about the relationships between or among variables and can be viewed as a possible solution to a problem. Observations, inferences, and predictions are usually employed to generate hypotheses; measuring and interpreting data may also be involved. Hypotheses are often assumed to be generalizations about observations or inferences.

Hypotheses are often referred to as "if-then" statements: If certain factors are present or if this is done, then this will happen. "If-then" statements are founded on data. Hypotheses are also stated as operational questions, which are often easier for some students to understand. Frequently, operational questions are tied to things, objects, or events that students have observed, experienced, or manipulated. Some hypotheses are really predictions of a cause-and-effect nature where the independent (manipulated) and dependent (responding) variables are operationally defined.

A hypothesis is an organizing structure for an experiment. It determines what is being tested and what to anticipate in the findings.

Interpreting Data. When interpreting data, the basic skills of using numbers and making conclusions are integrated. Interpreting data includes many subskills such as the ability to: 1) group data in a table, 2) construct bar and line graphs, 3) construct and interpret frequency distributions, 4) determine mean scores and ranges for sets of numbers, 5) employ slopes to interpret graphs, and 6) synthesize quantitative sentences to describe relationships between variables.

Through data interpretation, students explain, show relationships, or sort out what is happening during an experiment by using quantitative and/or qualitative data. In this way, they can determine the credibility of a hypothesis. Two fundamental outcomes from effectively interpreting data are the ability to avoid overgeneralizing and to draw imaginative and comprehensive conclusions. Interpreting data requires going beyond tabulating and graphing data: It involves the cognitive activities of analysis and synthesis.

Experimenting. The skill of experimenting allows students to develop skills in combining, at times in sequence, skills acquired from observing, classifying, inferring, measuring, communicating, predicting, defining operationally, formulating hypotheses, manipulating/controlling variables, and interpreting data in response to a problem. Other cognitive skill areas also brought into play are the use of cause-and-effect relationships and formal operational thought processes. Experimenting is the most comprehensive of the science process skills.

Students need practice to develop the skill of experimenting and should be encouraged to design and conduct their own experiments. Their results must be verified to determine validity and should be shared with other students.

Science Education Today

Lemons (1984) called for the traditional three R's to be expanded to include communication, higher-level problem-solving skills, and scientific and technological literacy. Supporting this position, Sigda (1983) concluded that science must make a strong comeback if we are to survive in a technological society. He characterized science education in the United States:

- There is a critical shortage of qualified science teachers.

- Since 1960 the average achievement in science on a variety of tests has shown steady decline.

- The average student will spend less than one in 25 instructional hours per week studying science in elementary school.

- Only 13 percent of general students and nine percent of vocational students will have taken three years of high school science.

- Science enrollments in high schools have been decreasing for nearly a decade.

- The movement away from science begins in the early grades.

- Only one in six high school juniors or seniors takes any science courses.

These facts are particularly discouraging when considering how high technology is influencing the workplace. Sigda (1983) notes that training and placement agency personnel for high-technology jobs say that a strong background in high school science, especially physics, is important to success in training and on the job.

Bill Aldridge, executive director of the National Science Teachers Association, collected data on the crisis in science teaching and found evidence supporting Sigda's conclusions. In addition to critical shortages of qualified secondary science teachers, Aldridge found that course content in secondary science is obsolete, science instruction has not changed to reflect what we now know about how students learn, classroom equipment and resources are outdated, and science teaching is disappearing in the elementary school. (Marcuccio 1983)

Marcuccio (1983) recommends that curriculum reform and refinement should not be dominated by higher education institutions; instead, it must involve both parents and local business to succeed. In addition, she contends that teachers should update their skills by pursuing training alternatives (e.g., rejoining the technological workforce during summer vacation). Marcuccio also proposes that teaching excellence be rewarded and a national course content created.

There have been other calls for business and industry links with education. It is commonly said that businesses and industries are losing their competitive edge because of their failure to respond to technological innovations. (Hassan n.d.) To counteract these problems, Abram, Rose, and Landrum (1983) suggest that educators, particularly vocational educators, work closely with high-technology industries to identify required skills for each training program. They have addressed five phases in the construction of such programs: 1) long-range planning, 2) program planning, 3) development, 4) implementation, and 5) evaluation and refinement.

In the long-range planning phase, the primary step is to establish a High-Technology Advisory Council. To this end, Indiana has established the Industrial Technology Education Curriculum Committee. The Committee's mission is to assist schools in establishing an effective technology education. The program established in Indiana is commonly referred to as "tech prep." This program could be initiated in the secondary vocational programs to prepare technologically literate workers.

Tech Prep

> As technological development continues at an accelerated rate, it will become increasingly difficult for people to understand these changes. Something must be done to prevent us from becoming a technologically illiterate nation. It is absolutely necessary for all people to understand technology if they are to function as citizens.... Therefore, a fundamental mission of schooling is to increase each person's ability to comprehend and apply the concepts of industrial and technological systems. This mission can best be accomplished through a revised and redirected industrial arts (industrial technology education) program. (Indiana Industrial Technology Education Curriculum Committee, 1985, pp. 1-2)

The subject matter area in the schools related to technological preparation is the industrial arts program, which has been commonly renamed Industrial Technology Education. While some basic curriculum development work has been done on the state, regional, and national levels, the Industrial Technology Education program will have a new thrust. The Indiana Industrial Education curriculum committee Association (1985) has developed three basic definitions to clarify the new direction in industrial arts:

- industrial arts/technology education is a general education program organized around a study of communication, construction, manufacturing, and transportation and is concerned with their technologies, industrial structures, and social/cultural impacts

- technology is the knowledge of efficient and appropriate action developed by humans to extend their potential for controlling their environment

- industry is an economic institution designed to produce goods, services, and information to meet human needs and wants.

With these guidelines, Indiana's industrial arts teachers and teacher educators are encouraging the redirection of industrial arts toward a more contemporary technology education emphasis.

Rudisill (1987) described postsecondary technology curricula as being in chaos and conflict; this is the area that prepares vocational technology teachers. Rudisill believes that a philosophical difference exists between technology education programs and industrial technology programs: the former is designed to teach technological literacy and the latter to teach management of technological systems. Industrial technology programs require greater applications of science, math, social science, and organizational management. A problem is that many schools house both types of programs and have students enrolled in the same technical course content, yet apparently they do not cooperate or coordinate in curriculum development efforts or promotion of technology education in higher education. A further problem in these programs is vague science and mathematics requirements. Even when the number of credit hours of science and mathematics requirements is specified, no mention is made of content depth. Many programs require basic chemistry and physics courses, but students studying technical subjects often need segments of science courses in greater depth. For example, a student in plastics manufacturing may need an understanding of organic chemistry. As technical depth increases in a vocational course sequence utilizing science principles the amount of time allotted to science will more nearly equal that allotted to the technical aspects.

A review of current efforts shows that leaders in technology-based programs in higher education must begin to cooperate and coordinate efforts in curriculum development. This effort should involve discussions with representatives from national organizations currently engaged in program development. Through cooperative efforts, sound technology-based programs can be developed to prepare vocational teachers.

Principles of Technology

The Indiana Commission on Vocational and Technical Education (ICVTE) supported infusing science and mathematics education into the vocational-technical education delivery system through a project titled "Strengthening the Science and Math Components in Vocational Programs Principles of Technology." The Principles of Technology program was developed cooperatively by the Center for Occupational Research and Development (CORD) in Waco, Texas; the Agency for Instructional Technology (AIT) in Bloomington, Ind.; and a consortium of 32 states and Canadian provinces. Four Indiana sites were selected in April 1985 to pilot test the materials. Three of the four sites actively participated in the two-year program, which ran from June 1984 to June 1986.

The Principles of Technology program was designed to be a two-year course but can be adapted to meet a variety of configurations. The program consists of 14 instructional units. A unit generally comprises 26 50-minute sessions. There are 80 video programs and a student text and teacher's guide for each unit; the guides include demonstrations. Each unit focuses on the application of basic science skills and principles underlying high technology in the workplace and deals with these principles as they apply to four kinds of systems (mechanical, fluid, electrical, and thermal) making up both the simplest and most complex technological devices and equipment. An additional program feature is that 40 percent of the student's time in each subunit is spent conducting hands-on lab exercises.

Conclusions: Science in Vocational Education

The science requirements of vocational programs vary widely at both the secondary and post-secondary levels. From the literature, it is evident that vocational students do not receive enough science applications. Worse yet, innovative science applications in vocational programs are rare.

Science skills cannot be overlooked any longer. Vocational students must learn that science is not conducted in isolation in a laboratory and that scientific knowledge and thinking is not confined to the health occupations. Science skills permeate the range of vocational-technical education occupations and will play an increasingly important role in the workplace. It is time to integrate science skills into the vocational-technical curriculum.

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CHAPTER FIVE

Computer Literacy and Basic Skills in Vocational Education

by

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THE WORK-EDUCATION BRIDGE

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The Office for Research in High Technology Education (Noyelle, 1984) reports that "nearly every recent educational study group and commission has recommended that computer literacy be included as one of the 'basics' in a core educational curriculum." But what is computer literacy? Is it indeed a basic skill? If so, for whom, and for what purpose? How does computer literacy relate to other basic skills and to the broader technological context? Finally, what vocational preparation is required to meet the challenges of a workplace steeped in technology?

This paper will examine various aspects of computer literacy as they relate to preparation for employment. Questions that will be addressed include:

o Are there basic computer skills and knowledge that are now required or which will be required of the majority of workers in the changing work force?

o What computer-related course content will be essential to all vocational preparation?

o What is the role of computers as a tool for preparing future workers? How are computers currently being used and what additional uses are possible?

o How can jobs in today's workplace be analyzed to determine their basic computer skills content?

o What is the social impact of computer technology and how has it changed people's intellectual processes and patterns of living?

To find answers to these questions we will review the literature on technology, computerization, and vocational education. The concluding section will summarize the literature review and will provide the authors' evaluations and speculations on the future of computer literacy in vocational education and in the workplace.

Technological Growth and the Job Market

A composite definition of technology as it is used in employment-related literature is "the know-how needed to apply information, techniques, and tools to material resources in order to achieve desired results." Just what this "know-how" will entail in the workplace of the future, who will need to acquire it, and what learning processes will be used have been the topic of heated debate in economic, political, and educational arenas for the past five years.

While it is generally accepted that technological growth will continue to make radical changes in work as we now know it, there are varying projections as to the economic and employment-related environments that will evolve. One argument advanced by futurists such as Stanley Pogrow of the University of Arizona is that there will be increasingly more jobs requiring technological competence as well as growing sophistication in the level of skills required by all workers.

Economist and educator Russell Rumberger is the chief proponent of a contrasting projection that high-tech jobs, while increasing rapidly in number, will not represent a significant percentage of all jobs in the marketplace. And in fact, there will be a net loss of jobs and technical skill requirements due to technological growth. Rumberger is in agreement with the futurists, however, in anticipating profound changes in the workstyle requirements of the future job market. As he sees it,

> Today's students must prepare for a future world of work that is essentially unknown. . . . In order to operate in such a world, workers will have to be flexible. As jobs change, they will have to acquire new job skills.
>
> The need to be flexible in the future world of work means that students will require a strong, basic education. They will need to master verbal, mathematical, communication and analytical skills. These skills will serve as a foundation upon which they can build new job skills as the need arises. (Demystifying High Technology 1984, p. 35)

Implications of Technology for Vocational Education

The uncertainty about the most appropriate response to encroaching technology is reflected in the literature devoted to assessing the implications of technology for employment-related training. Since *A Nation At Risk* was published in 1983, there have been fervent advocates for teaching skills in the public schools related to specific technologies. According to Gene Bottoms,

> The extent to which we can utilize high technology and translate it into better products and increased productivity depends upon availability of people who can apply it, maintain it, and service it. These people are not the scientists and the mathematicians--they are the advanced-level skilled workers. (1983, p. 8)

Secondary and postsecondary vocational education programs have traditionally emphasized computer-related skills and knowledge through specialized courses of study to train workers for occupations such as computer operator, word processing specialist, and data entry clerk. Although advancing technology has fostered an increasing integration of functions and less specialization, and has also demanded a greater variety of skills, the typical vocational education curriculum has continued to emphasize traditional, specific skills.

More recent programs may have added courses focused on newer technologies and more contemporary jobs (such as computer programming and computer-aided manufacturing and drafting), but suffer from the same problem of emphasizing overly specific and non-transferable, obsolescent skills. Researchers like Hunter and Aiken contend that this shift

> ...however well-intentioned, may be inappropriate. The job market is changing so rapidly that specialized vocational curricula may never catch up. For example, the supply of students trained in the traditional curriculum currently outstrips the demand. Instead, vocational educators may be better advised to teach their

> students general competencies such as problem-solving and communications skills. (1987, p. 54)

The National Science Foundation reported in 1980 that vocational course offerings might not be meeting the need for technological literacy among the majority of students who will not pursue professional or highly-skilled technical careers, or students who need more general information on topics such as computer use and technological change. According to Michael J. Dyrenfurth (1984),

> Typically, the new high-tech vocational education courses in robotics, electronics, and cable television teach only specific skills. In order to be technologically literate, students must gain an understanding of where specific learned technological capabilities fit into the overall system of technology. This would allow them to be more flexible when dealing with adjacent or new technologies upon entering the workforce. (p. 21)

Norton Grubb wrote that overstating the number of high-tech jobs that will be available and over estimating what can be done by vocational education to solve the country's employment problems,

> can lead too easily to preparing too many students for too few jobs, or to training students too elaborately for jobs that really need little more preparation than brief on-the-job training. (1984, p. 450)

Rob Melnick, Hudson Institute vice president, expressed a concurring opinion on secondary education. He said,

> In the context of rapidly changing technology, highly job-specific vocational education could be disastrous. It is likely that many occupational skills will become obsolete in a short period of time, particularly in jobs that are dependent upon technology. This does not mean we can ignore the immediate needs of employers who must secure workers with skills that are relevant today. However, to make vocational education occupationally specific at the expense of more generic skills is short-sighted. (Educating Youth for Work: The Role of the Private Sector, 1986 p. 2)

The view that workers with a solid basic education rather than narrow vocational training are preferred by employers is shared by Peter Elliman of Lucas Industries. He said,

> I would much prefer that the schools concentrate on teaching their students the basic, transferrable vocational skills that they will need when I teach them the applied technology I utilize. (1983, p.4)

Skills Basic to Technological Preparation

Since only a small segment of the population is expected to need extensive technical knowledge of computers to perform their jobs, the U.S. Department of Labor advocates stressing "a solid grounding in English comprehension and communication, mathematics, and problem-solving--the basic skills" which, in the Labor Department's view, are and will be critical for all workers. (National Commission for Employment Policy, 1986)

Tesolowski and Roth, in a 1985 paper presented to the American Vocational Association, pointed to the need in some occupations for workers to be able to read instruction manuals for the equipment and software they are required to use. They assert that in all occupations where computers are used, workers are called on at times to make educated judgments about the accuracy of the words or data they are processing. New technologies increase the worker's responsibility for production, they argue, for instance by replacing rote manual labor with the performance of more abstract tasks.

A report by Moon and Weaver in 1984 for the Business/Industry Task Force concluded from a survey of business organizations that,

> the major areas of weakness for word processing specialists include inadequate language arts skills (45%), inadequate knowledge of spelling (39%), inadequate vocabulary (39%), and inadequate training on word processing equipment (33%). (p. 5)

The Task Force's recommendation for realistically preparing students for entry-level jobs in modern business offices included the suggestion that schools,

> teach basic language skills (grammar, punctuation, spelling, capitalization, word usage) from an applied point of view in the business department. (p. 5)

Yet a search of relatively recent task lists developed for office occupations as well as for a number of other technologically-related occupations revealed no mention of word processing or other computer-related skills, and relatively little emphasis on basic academic skills.

A College Board survey conducted in 1983 found that business and industrial leaders defined "basic academic competencies" as broad intellectual skills providing,

> a link across the disciplines of knowledge although they are not specific to any particular discipline--skills enabling people to adapt to new knowledge and situations. (p. 70)

Crohn reported in 1983 that business leaders who emphasized basic, rather than job-specific, skills wanted students who had been taught decision-making skills in order to help them better understand adult responsibility. Rumberger (1984) prescribes an education that utilizes processes of analyzing and synthesizing information to solve problems and to make decisions, processes which he labels "higher-order intellectual skills." Many of these skills now considered to be of a "higher" level, which also include skills in planning, applying principles and concepts, and abstract reasoning, are the potential basic skills of tomorrow. Additional broadly applicable, transferable skills include the ability to be flexible, adaptable, and to initiate and respond to changes in work environments in a positive way. New technologies require interdependence of jobs and encourage the ability to perform a number of jobs interchangeably. Therefore, essential, nontechnical, basic skills also include interpersonal and group process skills as well as skills in business economics, organizational management, and quality control. Finally, there is an emphasis on developing students' confidence in their ability to learn new concepts and to use new tools and techniques.

What Is Computer Literacy?

In an examination of the groundwork that has been laid for the infusion of computer literacy outside the specialized high-tech vocational courses, public understanding of computer applications has not kept pace with availability and use. It has been reported that junior and senior high school students understand very little about computers and their implications for society, much less their limitations. More than half of the 1,500 students in a recent survey believed that by providing correct answers to any question computers help people make decisions.

While researchers would agree that this attitude is an example of computer illiteracy, approaches to addressing such misconceptions and for fostering competency with the computer differ. As Levin (1984) states,

> An exact definition of computer literacy seems to vary from mere exposure to computer concepts and functions to the learning of at least one programming language, to the mastery of problem-solving techniques using computers. (p. 16)

The most common theme in computer literacy definitions is the ability to use the hardware and software to accomplish some goal. M. James Bensen (1984), substitutes for "literacy" the term "operacy," which includes, in addition to general knowledge needed by all, the notion of a set of competencies that everyone should have in order to be able to do computers.

A composite definition of literacy would include understanding what the computer can and cannot do, and knowing how and when its strengths and limitations as a tool can be applied to "valid purposes" such as solving problems and making decisions in a "computer-prominent" society. There is a sense that there may be varying levels of competency appropriate to different levels of functioning in society, though there is a seeming reluctance to commit to prescriptions for varying levels of training beyond obvious job-specific differences (for example the different training required by a systems analyst and an automated office worker).

Computers As The Focus of Instruction

To the inexperienced, computer technology is an esoteric phenomenon reserved for those with high intelligence and college degrees. Students commonly express fear that they will somehow damage the computer by experimenting with it or that it will mysteriously consume the product of their time and labor and leave them with an empty screen. Thus perhaps the most urgent focus on computer education suggested by the literature review is to reduce the fear that results from dealing with the unknown--a focus which is compatible with the literature cited earlier which calls for a workforce that is comfortable with uncertainty and change.

An historical overview of computer development from mainframe to mini to micro, of its hardware and software components, and math/engineering principles may cultivate an appreciation for its potency and limitations as well as an understanding of its impact on the lives of workers and consumers in our technological society.

Another important issue to address in determining the focus of computer instruction is the debate over programming and its benefits. Niman (1985) asserts that computer programming is important because it encourages students to think algorithmically and develop problem-solving skills. Niman said,

> Programming involves writing a set of instructions that tell the computer how to accomplish a specific task. It requires the development of an algorithm or procedure for solving a specific problem. This essential element in programming leads to the acquisi-

> tion of new concepts--such as iteration (the process of repetition, using a formula or procedure to solve a problem), structure, and logic--thus deepening the meaning of literacy. (p. 24)

And as Papert describes it,

> The child programs the computer and, in doing so, both acquires a sense of mastery over a piece of the most modern and powerful technology and establishes an intimate contact with some of the deepest ideas from science, from mathematics, and from the art of intellectual model building. (1980, p. 5)

Special programming languages have been designed for use by children. These languages permit creation of learning environments that specifically enhance the development of a child's intellect. Though critics like Menosky (1984) express doubt as to the generalizability of Papert's findings, there is an undeniable commitment by computer literacy advocates to the belief that learning how to program leads to conceptually clear thinking and to improved skills in dealing with complex problems.

The Computer as a Work Aid or Tool

There are a number of specific computer applications that are appropriate to a computer literacy program. Computers can be used as a diagnostic tool and to manipulate large database files, such as personnel records. They can be used for the generic processing of text or visual images, and as a monitoring device. Computers can be used to create spreadsheets, for extrapolation, synthesis, ledgers, accounting sheets, calculating, arithmetics, scientific analysis, decision trees, and scenarios. Finally, they can be used as a control device for other mechanicals.

Many computer literacy advocates insist that keyboarding is a transferable skill that should be taught to all students, regardless of vocational specialization, though the advent of the mouse- and voice-activated accessing methods may eventually render the keyboard obsolete. Other applications which may constitute transferable skill include database and data manipulation, word processing, and files and filing systems.

Wagoner (1982) suggests that there are skills and awarenesses which, in addition to keyboarding, would prove useful as preparation across different word processing programs and tasks. Some of these include:

> o An understanding of information flow and the information cycle.
>
> o An understanding of computer technology and how the computer (word processor) can be used to process information effectively and to perform many tasks more efficiently.
>
> o A conceptual understanding of the use of a database and an understanding of electronic files and how to store information for retrieval and future use.
>
> o Formatting skills--the ability to organize and handle creatively the setting up of various kinds of documents.... including facility with inserting, deleting, and moving blocks of information.
>
> o Editing and application of language or verbal skills--including vocabulary,spelling, grammar, and knowledge of punctuation.

o Proofreading skills--the ability to find both typographical and content errors. (pp. 44-5)

Perhaps the best summarization of the status of literacy training is a remark by Konar, et al (1986) that,

> In a very real sense, computer literacy is a moving target.... The meaning of computer literacy will change over time and so will criteria for changing it.... Unlike language literacy, computer literacy cannot be maintained through simple use. And by extension, today's literacy training program must be updated to be of value in the years to come. (p. 86)

Computers As Instructional Technology

Perhaps the most clearly documented success with using computers in the classroom has been with Computer-Assisted Instruction (CAI). CAI as defined by Coburn, et al. (1982) consists of computer applications involving conventional educational methods used to pursue traditional educational goals. In this context, the computer is an electronic aid to the teacher--CAI programs are teachers' instructional materials in which teaching methods are embedded.

An examination of the literature revealed seven computer-based training methodologies, which in practice are delivered independently or in various combinations. The first, tutorials, are used to introduce the learner to concepts and information for the first time. The process is similar to a Socratic dialogue, where information is presented followed by a series of questions.

Drill and practice is a training methodology which assumes that the basic concepts have been introduced through another medium. The function of the computer here is to provide repetitive reinforcement of concepts. Daniels, et al. (1985) report that software is now available for most vocational basic skills areas, including vocabulary building and mathematics problems.

Simulations can provide a scaled-down, real-life situation, including concepts, processes, training, role playing, or machine operation, without tying up expensive equipment or exposing learners to actual risks. According to Coburn, et al. (1982), the real power of simulation appears to be the advanced-level thinking and problem-solving skills required to test hypotheses by manipulating variables. Simulations can, however, also be used to teach content, for concept development, to master skills, to promote inquiry, and to stimulate student interest.

Demonstrations involve the use of graphics, sound, and/or color to assist the teacher in primary instruction or to assist students in their review.

Discovery programs require a student to investigate, organize and plan, develop strategies, and make calculations. These parallel real-life situations and aim toward the greater level of understanding attainable through creative problem-solving.

Instructional games employ a set of rules and usually have a winning strategy. With selected software, basic concepts or skills in the vocational area and problem-solving skills are utilized to win. The entertainment element of these games appear to increase the chances of the student learning the knowledge, concept, or skill embedded in the game. Advantages of gaming are: problem solving, learning about language, thinking, reading, learning how to process facts and make logical inferences, and developing estimation strategies.

Finally, computer-managed instruction enables computerized record-keeping and test administration as well as directs trainees toward other sources of learning such as texts, hands-on materials, and videotapes. It also enables testing of trainee mastery of these other learning resources.

Anandam (1986) reported the following advantages of instructional computer use:

- o Information presented in a classroom during a semester can instead be delivered by computers in a matter of hours or minutes.
- o Computers are perceived as consistent, patient, and fair by students from minority groups.
- o Computer-based instruction is more effective at raising achievement amoung low and high-achieving students than it is among students of average achievement.
- o Computer-based software that is integrated into the curriculum has a better chance of yielding positive results.
- o Computer-based education leads to improved attendance, increased motivation, longer attention span, and significant positive change in student attitudes.

Integrating Basic Computer Skills into the Vocational Education Curriculum

Like the majority of the participants in the technology debate, Smith and Stallard (1984) called for a greater emphasis to be placed on reassessing traditional occupations curricula rather than on developing curricula exclusively for emerging occupations. In order to make learning transferrable, they perceive a need to stress basic functions, capabilities, and limitations of vocational programs. They assert:

> Traditionally, computer-related skills and knowledge have been taught in separate courses for computer-specialist careers such as data entry and computer operations. Now, computer-related skills and tools must be integrated into all areas of the vocational education curriculum, both to prepare students for the workplace and to improve their productivity as they learn.

Strategies for infusing computers into vocational programs include: 1) using computers as tools; 2) integrating computers into the vocational curriculum; and 3) reassessing and restructuring basic curricula in light of computer-based methods of working.

Rodenstein and Lambert (1982) suggested further guidelines for designing and selecting competency-based computerized instruction for vocational education programs. These guidelines prescribed maximum control over the sequence and difficulty level of programs; a degree of individualization; modules structured into flowchart format; emphasis on mastery of performance objectives (including pre-tests and progress evaluation); multisensory presentation; appropriateness for age group; well-written in terms of accuracy, grammar, clarity of instructions, involvement, etc.; ability to hold interest; appropriate graphics; freedom from bugs; perceptual impact of text material; clear instructions; examples; program control; instructional dialog. In light of the fact that programmers are not always educators and educators are not usually programmers, they also recommended that special attention be paid to the degree to that the learning process--cognitive development, educational psychology, and adaptive instruction--has been addressed.

In a 1984 study of the effects of recent legislation on secondary vocational education, Margaret Ferqueron expressed concern that the increased emphasis on basic academic skills not deprive students of enough employment-related coursework for the workplace. She added "It is extremely important that state leaders recognize that students may achieve competencies *within* vocational courses." In addition, Ferqueron believes that vocational and academic teachers,

> must work together to show those who legislate educational reforms that secondary education is not an either-or, single-track battle between liberal arts and practical studies.... They must work together to show legislators that students who so desire can learn academic skills in vocational courses. And they must work together, with business and industry, to ensure that increased graduation requirements, or a "return to the basics," are designed so that students are better prepared, not less prepared, to enter our high tech future. (p.38)

Instructional Materials for Delivering Basic Computer Skills

While there is a notable lack of materials designed specifically to deliver basic computer skills into the vocational curriculum, the Hardin County Board of Education in Elizabethtown, Kentucky created two in-service manuals in 1985 for vocational educators to use to this end. One sample lesson required students to complete a computer-assisted exercise in which they were to correct the spellings of employment-related vocabulary words. Other units included computerized lessons combining basic mathematics skills with business budgeting, problem-solving skills combined with the computation of mathematical averages and fractions, units combining job responsibility and goal setting, and word processing business letters and job applications.

Kiteka (1987) has developed an application package described in a monograph called *An Exercise in Desktop Publishing: Using the "Newsroom,"* which can be used to integrate language arts and computer skills. The monograph contains step-by-step procedures for creating text and graphics for a sample publication with the "Newsroom" software.

Computer Delivery of Basic Skills

According to The National Science Board Commission on Precollege Education in Mathematics, Science, and Technology, the major focus of research and development in educational computing, defined as learning through computers and measured in effort and dollars spent, has been on drill-and-practice, diagnostic testing, and question-and-answer tutorials. The Commission concludes "There is a body of research attesting to the effectiveness of this mode of learning compared to conventional instruction," and projects that interactive computer resources, including access to word processing, databases, graphic capabilities and host of related means to expand students' learning potential could simultaneously provide a new standard of achievement and lower the cost of education. (Educating Americans for the 21st Century, 1983, p. xi-xii)

Coburn, et al. (1982) report that teachers who use word processing with students find that even the young ones will revise their work to correct spelling, punctuation, word selection, sentence structure, juxtaposition, etc. They report that students who ordinarily avoid writing become more enthusiastic about writing. All these students tended to write lengthier, more detailed essays and stories. Word processing also appears to foster overall improvement in the ability to follow directions.

The National Science Board Commission particularly commended educational games, (such as adventure games) as delivery systems for teaching basic skills. According to the Commission, these games "develop reading comprehension and problem-solving skills and discovery learning in mathematics," which provides a more active and self-directed learning environment within which the student can discover properties of mathematical functions and operations. (Educating Americans for the 21st Century, 1983, p. 53)

Sequencing Basic Computer Literacy Skills Training

Konar, Kraut, and Wong (1986) proposed a framework for conceptualizing and sequencing computer-literacy activities which identified three major components: awareness, skill, and knowledge.

Awareness is defined by the authors as "familiarity with the capabilities, advantages, limitations, and impact of computer technology." It tends to precede user capability in that it generates interest in the technology and its use. The authors postulate that,

> only by seeing what is possible does one become interested in acquiring expertise and capable of setting appropriate educational goals. (p. 83)

And furthermore, they say,

> Until one has an elementary view of the possibilities in computer use, developing skills and knowledge seems less meaningful or attainable. (p. 85)

The authors recommend a brief demonstration of the potential applications or uses of a relatively basic system to foster awareness. They suggest that beginning with awareness is most likely to reduce resistance or its magnitude.

Skill, according to the authors, has an immediate payoff in giving a person the ability to accomplish valued goals. The payoff may be in accomplishing a task faster, more accurately, or better than before or it may be in reducing the drudgery of a repetitive task. For many people, the most concrete representation of computer literacy is in such skills. (p. 83)

After awareness has been aroused, next in order is a skill building activity comprised of exercises which develop a sense of competency in using the technology. This includes instruction in the use of a simple, relevant application which is of interest to the learner.

The authors suggest that one can make an argument for starting with the skill component because it provides a chance to perform, promotes increased awareness, and furthers motivation to learn.

Knowledge is defined by the authors as "an understanding of the technical workings of the equipment; how the system functions internally." Questions regarding the technological knowledge component follow naturally from questions which arise in acquiring the skills necessary for accomplishing the task or using the application (for example, why things are done in a certain sequence). The authors assert that,

> motivation to understand the technology is strongest when it stems from and relates to difficulties in use. . . . This component should come last, as beginning with this component may cause or exacerbate resistance or its magnitude. (p. 86)

The authors summarize their sequencing proposal by saying,

> with basic knowledge and skills, one can use existing documentation to learn to do new things, make skills learned on one system more readily transferable to a new system, and provide the ability to recover from or bypass unexpected problems in using a system..... Awareness, skills and knowledge in combination provide the flexibility and capability to meet task or job demands, and even an ability to redesign the work or task process to make effective use of the technology. . . . Together they provide a level of confidence that encourages further learning, and an ability to transfer experience and education to new users. Ultimately these are essential in attaining the improvements productivity and quality made possible by the Information Age. (p. 84)

Hunter and Aiken (1987) reported yet another sequence of universal computer literacy objectives which were to be integrated into the regular math, science, language arts, and social studies curricula. They are:

1. Using and developing procedures. This track emphasizes procedural thinking as fundamental to both understanding and using computers.

2. Using computer programs. The use of a variety of computer programs is seen in this track as prerequisite to understanding how computers can be applied to different kinds of tasks and what the computer's capabilities and limitations are in doing those tasks.

3. Fundamental concepts about computers. This track is limited to a few very basic concepts, such as the idea of a stored program.

4. Computer applications. The emphasis in this track is on understanding computer-based systems, including the interaction of people, machines, data, and procedures in performing tasks.

5. Impact of computers on society. The emphasis in this track is on relationships among people and between individuals and society, and the effect of computer-based systems and related technologies on these relationships.

6. Writing computer programs. This track emphasizes the systematic problem-solving processes involved in developing and writing computer programs for particular tasks.

Impediments to the Delivery of Basic Computer Skills

Reports indicate that between 1983 and 1985 the use of computers in kindergarten through grade twelve rose from 250,000 to over 1 million, and the number is still climbing. Approximately 150 to 200 new educational software packages are produced each month. Thus, it is no surprise that a general lack of teacher preparation is often cited in the literature as a major obstacle to the successful delivery of basic skills via computer technology in vocational classrooms. Teselowski and Roth (1985) reported that,

> the rapid influx of microcomputers into vocational classrooms and laboratories has caught many educators unprepared to effectively utilize this contemporary instructional technology. (p. 4)

Voegel (1986) said that technological devices introduced into the classroom have historically "had marginal impact on the overall teaching-learning process." Anandam (1986) observes that,

> In today's application of technology, it is sad to note that hardly anything seems to change in classroom instruction as we know it. (p. 70)

It was Goodlad's (1984) conclusion that,

> the technological revolution appears to be sweeping around schools, leaving them virtually untouched, even while purchasing microcomputers is becoming the "in" thing for school districts to do. (p. 340)

The National Science Commission on Precollege Education in Mathematics, Science, and Technology calls attention to

> a substantial gap in perception as to the utility of these [computerized instructional] systems between the producers and the teachers who must apply them. Producers must provide materials that are appropriate to teachers' needs, and teachers must be provided with the necessary training to apply this technology effectively. (Educating Americans for the 21st Century, p. 53)

The Office for Research in High Technology Education (1984) cited a survey which named inadequate budgets for change as the primary problem facing computer literacy in vocational education. The Office reported that in the 1979-80 school year, secondary-level vocational education institutions spent nothing on new programs. Ninety percent spent less than five percent on new services.

According to a 1985 study by Teselowski and Roth, which was aimed at identifying, verifying, and determining the importance of various teacher competencies for applying microcomputers to the vocational classroom, vocational educators were apparently most concerned with the actual implementation of computer-based instruction. They ranked the following seven competencies as being of utmost importance:

1. selecting appropriate software for specific instructional purposes;

2. orienting students to Computer-Based Instruction (CBI);

3. identifying job-specific applications of microcomputers for inclusion in vocational curricula;

4. creating authorized back-up copies of microcomputer software;

5. executing CBI;

6. developing a plan to apply CBI to vocational curricula;

7. identifying educational applications of microcomputers for inclusion in vocational curricula.

Vocational educators questioned by Teselowski for this study did not feel a need to become competent in developing software or in performing classroom management functions through computer-based instruction.

The WEB Model As a Computer Literacy Tool

It is in the areas of identifying job-specific and educational applications of microcomputers for inclusion in vocational curricula and developing a plan for applying them that the Work-Education Bridge (WEB) model offers the greatest possibilities.

The Office for Research in High Technology Education (Grubb, 1984) pointed to a need for more systematic and comprehensive information on computer-related skills that will be used in the workplace of the future. The Office also said that current methods for devising job and task inventories are inadequate for keeping pace with change.

Some of these changes were documented by WEB researcher Debra Moore in her task analyses in the Hunt-Wesson and Westinghouse manufacturing plants. According to Moore, computers are integral to the automation of these workplaces, thus requiring that more employees become computer literate. Because many machines are computer-controlled, their operators must now have the ability to manipulate a keyboard and know how to execute and abandon operations.

Computerization has changed quality control activities as well. Quality control was traditionally a personal operation, where an employee used visual and hand instruments to take measurements, which were then recorded on a simple form with pen and pencil. New computerized methods of quality control involve workers in activities ranging from calculating simple statistics read from a computerized machine to taking readings with hand-held machines that are connected to computers.

Task analysis is generally used to identify the performance requirements (such as what, how, when, where, and for how long a task is performed), plus the knowledge and skills, technical, judgemental, and academic that are needed for successful completion of the task. From her task analyses, Moore has abstracted the following transferrable, comuputer-related skills, which can be translated into vocational education curricula and activities:

1. Keyboarding skills, such as letter and number recognition as well as facility in accessing the various keys.

2. The ability to use control features, to move from one screen to the next and up and down a page.

3. Order, logic, sequencing, and problem-solving skills which are needed to follow through a complex task.

4. The ability to assess whether one has correctly programmed the computer to perform a given task.

5. Ability to know when it is necessary to execute, change, or abandon a task sequence.

6. How to use one computer function to check and correct another computer function.

7. The ability to adapt and make changes in a program.

8. How to use data once it is obtained; how to adjust procedures based on obtained information.

Social Issues

Another issue of great concern to computer literacy researchers is how to equally prepare all interested students to cope with a computerized workplace. Researchers and educators on all sides of the literacy debate agree that high technology can either enhance or reduce both the quality of life in the workplace and the utilization of worker skills.

In the past, technological innovations displaced unskilled physical labor. In the workplace of the future, micro-electronic-based technologies are likely to displace the skilled mental labor of many white-color workers as well. The skill composition of the future workplace will ultimately depend on just how the equation of human development and production goals is finally balanced.

Despite the fact that the Carl D. Perkins Vocational Education Act of 1984 requires that funds be set aside to ensure access for women, disadvantaged, and disabled students to high quality vocational education programs, including computer and technical education, there is a growing concern that biases in software selection and in administrative policies and teaching practices discourage female students from participating fully in computer literacy programs. There is also concern that the prohibitive costs of computer equipment may further disadvantage poor students relative to their middle-class counterparts. The disparity in access to technology based on socio-economic group is widening the gap in the future employability of these already disadvantaged groups and women when compared to middle-class males.

Consider the 1980 Census data indicating that 90 percent of parents in the eastern United States who were in the upper 10 percent income bracket owned a home computer system and both educational and business software, while only 20 percent of those in the lowest 10 percent income range owned a computer, which usually consisted of a joystick and computer games. By the year 2000, it is projected that 25 percent of the most affluent school districts will have a 1 to 4 ratio of computers to students while 25 percent of the poorest schools will have 1 computer for every 8 students. (Cetron, 1985)

Economist Marc Porat envisions social classes of the not-too-distant future, which divide the information poor from the information rich, those who have access to information from those who don't. As he stated it in 1978,

> The essence of the information society has to do with power. It has to do with the difference between success and failure, survival and defeat, powerfulness and powerlessness. And it hinges more than ever before on understanding the value of information....how to get it, organize it, protect it, use it, see it, and not get overwhelmed by it. In an agricultural society, the source of power is land. In the industrial society, the source of power is capital. Where is power in the information age? In the information society, information is power. (1978)

In order to "neutralize biased images and to encourage girls, minority students and disabled students to participate fully" in computer literacy programs, the National Center for Computer Equity recommends that such programs be integrated with the core curriculum of all schools and supported by state governments by providing:

1. teacher training;

2. the evaluation of software for quality and lack of bias;

3. model computer literacy programs;

4. information on new applications of computers to learning;

5. information on how to plan and implement a computer education program;

6. information on equity issues in computer education programs and how to build equity goals into the overall program. (Programming Equity into Computer Education, 1985)

Evaluation and Conclusion

The battle rages on between the futurists who predict a future in which technology will raise technological skill requirements and job possibilities and those who foresee lowered requirements and openings. Yet the literature related to computer literacy and its larger technological context, even as described by those who argue for a less skilled workforce, yields at least one unmistakable conclusion for today: Computer technology is now so pervasive in the workplace, and its impact on the thought patterns and workstyles of current workers so profound, that vocational educators simply must address computer literacy in their curricula to stay current with the changes in the workplace.

Moreover, it seems clear that a frantic expenditure of scarce resources to perpetually replace computerized machinery before it becomes obsolete is not only an impractical but impossible method of preparing students for the rapid changes in the workforce. Existing technology can best be used to teach skills that transfer across technological devices and from job to job. Employers assert that it is their role to train workers in the specifics, a task that they find easier to accomplish when workers come equipped with the basics.

The basics for nearly any job seem to include a reasonable level of academic proficiency in reading and math. The rapidity of change also makes personal skills such as flexibility, adaptability, and the ability to initiate and respond positively to changes in the workforce mandatory skills for most workers. And for many workers in the information society, there will also be a need for higher-order thinking skills such as problem-solving and decision-making.

Computers have a demonstrated capability for furthering each of these new required clusters of skills. As the delivery mechanism for basic academic skills, as the stimulus to productive thought, or as a doorway to the complexities of an age where information is the source of power, the computer can be specifically applied to creating a vocational education curriculum which genuinely reflects the demands of a changing workplace and meets the needs of tomorrow's workers.

The sociological, political, economic, historical, and developmental aspects of computers, along with instruction in their application and use, are a necessary background for fostering citizens who have an appreciation for computers and a recognition of their potential to shape the future. There is a capability for enslavement in technology that can only be thwarted by a realistic appreciation for its possibilities and limitations. Far from advocating technological indoctrination, this line of thought results from a desire to achieve a place of balance for computers, and their parent technologies, within the larger societal context.

Important as this background information may be, it is actually prevocational in nature. Computer technology as it is applied to the vocational context accentuates the fundamental mission of vocational education, which has always been to model its instruction for the workplace after the demands of the workplace. It is clear from the literature review that there is a demand in today's workplace for employees who understand the basic principles underlying today's technology.

Computer training in the vocational classroom cannot be taught as an appendage to the vocational curriculum. If workers are expected to understand the essence of computer technology in order to learn and perform a variety of on-the-job tasks, then their vocational education must include opportunities to manipulate the computer under a variety of conditions and for varying purposes. The desired outcome of vocational preparation is an attitude of openness toward learning technological tasks rather than specific knowledge of specific hardware and software, if graduates of vocational schools are to emerge as problem-solvers focused on inputs and outcomes rather than as the off-the-shelf containers of one or two obsolescent skills.

In summary, throughout the literature there is a plea for what MacKenzie (1983) called a "nationwide manpower plan" to provide adequate training and retraining for the rapid changes in the workplace brought about in part by computerization. At the very least, there is a plea for state and school system-wide planning and resource allocation to ensure the equal and timely application of the most current information about computer technology and of basic computer skills to vocational programs and curricula.

A body of concrete research, which ties computer literacy and basic skills to vocational education is profound in its absence. Only a few studies on the effectiveness of computer-assisted instruction have been conducted; certainly not enough to provide a basis for designing vocational curricula which integrate basic computer skills and experiences. The existing literature is comprised mainly of well-thought out and provocative expert judgments. All of these writings will be invaluable in articulating and formulating an eventual delivery system for basic skills in vocational education. But none of these pronouncements is adequate without a hands-on excursion of policy makers and researchers into vocational classrooms and the workplace to study and report on computers in the act of teaching basic skills to the workers of today and tomorrow.

The WEB model's potential for identifying and delivering hands-on vocational instruction that meets the demands of the workplace is broad and very promising. In WEB's first application to analyzing the computer content of the manufacturing industry, it unearthed transferable manipulation skills that coincided with the recommendations of corporate computer trainers. It recorded worker activities that support the call from computer theorists for logic, sequencing, and programming skills. Perhaps most significantly, WEB identified skills used in an array of computer-related problem-solving, decision-making, and flexible tasks which exemplify not only the workplace described by educational futurists, but through task analysis performed within the WEB framework, vocational educators have the opportunity to design and redesign vocational curricula which accurately represent the work world into which their students will enter in today's complex information society.

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CHAPTER SIX

Indiana Commission on Vocational and Technical Education Projects and Initiatives: The Impact and Potential for Basic Academic Skills

by

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THE WORK-EDUCATION BRIDGE

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Introduction

This paper discusses the basic skills impact and potential of projects and initiatives of the Indiana Commission on Vocational and Technical Education (ICVTE). The paper reviews three recent, ICVTE-funded projects: Principles of Technology (PT), Applied Mathematics (AM), and Applied Communication (AC). In addition, the paper will discuss the Indiana legislative initiative on technology preparation (IC 20.10.1.5.6) in relation to basic academic skills.

Applied Mathematics is a project being developed by the Center for Occupational Research and Development (CORD). Applied Communication is a project being developed by the Agency for Instructional Technology (AIT). Principles of Technology was a collaborative venture between CORD and AIT. These three projects have been funded by a consortium of states and provinces. Indiana, through the ICVTE, is a member of this consortium.

Principles of Technology

Principles of Technology (PT) is a two-year secondary-level program in applied physics, targeted toward eleventh-grade and twelfth-grade students in vocational education.

Prerequisites for students of PT are an eighth-grade reading level and completion of a first course in algebra. The algebra course may be taken concurrently.

A forecast readability analysis of student materials indicates that PT reading levels are between the tenth and eleventh grade for both years of the program. The relatively high level of reading combined with the algebra requirement may deter or deflect many of the students who could benefit most from an applied curriculum. Basic academic skills are clearly necessary for students to succeed in PT.

Where PT is implemented in its entire 14 unit sequence, it is especially important to provide students with academic support. Screening of enrollees to determine basic academic skills competencies may be necessary. Corollary enrollment in basic academic skills courses may also be necessary for some students. A strategy recommended by the Work-Education Bridge (WEB) research team is to integrate basic academic skills instruction into the applied physics course.

Although highly-motivated students will likely succeed in PT, in spite of a reading or mathematics deficit, students with academic difficulties, generally, may be expected to struggle in PT. In Indiana, where secondary vocational education has taken the lead in implementing PT, there may be a shortage of qualified students for PT; however, there is an abundance of qualifiable students in secondary vocational education. The importance of basic academic support systems must be emphasized, if student qualifications are to be realized. The applied nature of PT may provide students with an appealing context for the development of basic academic skills.

The PT program yields a wealth of options for the development of customized instructional materials in basic science skills for employment. The 14 units include 104 laboratory exercises, 52 teacher demonstrations, and more than eight hours of video tapes.

The PT video tapes are particularly useful introductions to applied physics concepts for nontraditional student audiences. They provide accessible introductions that may alleviate learners' fears. These initial presentations are especially important in worker retraining programs where trainees experience job insecurity because of technological change.

The Principles of Technology program is relevant to a wide range of workplace technologies. It employs a systems approach that integrates the applications of physical systems across various occupations. For example, a worker familiar with an energy system application in a specific occupation may learn the transferable elements of that system for application to another occupation or range of occupations.

Applied Mathematics

Applied Mathematics (AM) is a two-semester modular competency-based mathematics program primarily intended for vocational high school students but also appropriate for employees and other adult learners.
In "Basic Mathematical Skills in Vocational Education" (Kloosterman and Gillie, 1987), the authors stress the value of mathematical understanding that derives from problem-solving applications. They also stress the importance of applications that are relevant to the student's vocational interest. The CORD project AM is based upon similar assumptions. The project prospectus states:

> The greatest transfer of skills occurs when they are learned in situations similar to those in which they will be applied. Therefore, this course will focus on mathematics problem-solving activities that students will find relevant to their vocational interests.

According to the prospectus, AM will cover approximately 25 units; each unit is structured according to the following pattern:

1. exploring the concept,
2. seeing how the concept is used, and
3. applying the concept.

Level I (first semester) materials are scheduled to be completed and available for use in January 1988. Level II (second semester) materials are slated to be completed and available for use in July 1988.

AM may be employed as a two-semester course or may be infused in occupational courses. The flexibility that the modular, competency-based design affords leads to a wide variety of implementations. The emphasis on applications makes the program attractive to designers of hands-on instructional programs.

AM consists of a video program, student text, and teacher's manual for each unit. The video programs are brief (10 minute) introductions to mathematics topics. The videos are an attempt to address math anxiety through the use of a familiar, non-threatening medium. As with Principles of Technology, the video presentations may be particularly helpful for adult learners.

Applied Communication

Applied Communication (AC) is a one-year language arts program that is composed of approximately 15 units of instruction, each containing approximately 10 lessons. The program will be offered as a stand-alone course or as units integrated into another course. The competency-based instruction is directed toward students in secondary vocational education.

According to "Instructional Design for Applied Communication," the primary target audience is eleventh- and twelfth-grade students. Other audiences include ninth- and tenth-grade students and postsecondary, adult education, and retraining classes.

The AC project reflects the growing body of literature that proposes functional context learning as a means of bridging academic and job skills. It incorporates a "systems approach" in the curriculum; this approach provides an overarching structure for students to use in problem solving, thinking systematically, and integrating bits of information into meaningful wholes.

Each AC unit includes two 10-minute video programs, student and teacher print materials, and problem-solving applications from a variety of occupational settings.

According to the prospectus, student prerequisites for AC are the ability to read and understand materials written at the sixth-grade level and the ability to write an expository paragraph describing an object or system.

Beginning units of AC will be available for classroom use in September 1988, according to the AIT project prospectus.

Developing Instructional Materials for the Workplace

All of the above curriculum packages are useful in the development of customized instructional materials for the workplace. Frequently, there are basic academic contents required for specific occupational instruction. The modular units of PT, AM, and AC provide valuable off-the-shelf resources for developers of functional context learning programs.

The WEB conception of functional context learning materials for job-related academic skill instruction is to extract information from the workplace manuals, measuring devices, communications, calculations, standards, etc. for incorporation into lessons that are integrated with specific skill training.

Frequently, the academic content of an occupation implies foundation skills that are essential for job performance. The modular lessons of PT, AM, and AC may provide an adaptable instructional resource for attending to these foundation skills.

Technology Preparation

The 1987 session of the Indiana legislature yielded legislation that created a technology preparation task force "established to design and approve technology preparation curriculum models." The legislation directed the task force to develop curriculum models that "include math, science, and English language arts courses, taught through practical application and designed to meet graduation requirements for those courses."

The legislation requires that curriculum models must:

- be performance-based;
- provide students with the skills necessary to gain employment or pursue further education upon graduation;
- relate to a broad scope of occupational opportunities;
- be designed to include secondary and postsecondary sequence models; and
- allow for dual credit, advanced study, and cooperative agreements.

The applied academic offerings of Principles of Technology, Applied Mathematics, and Applied Communication are curricula that the technology preparation task force undoubtedly will review in its pursuit of curricula to approve for Indiana schools.

The Work-Education Bridge offers a means to develop curricula through occupational task analysis of basic academic skills content and incorporation of work-related materials into instruction. This methodology for integrating basic academic skills instruction with job preparation merits consideration by the task force as one model for the development of technology preparation curricula.

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